Wind Energy Update

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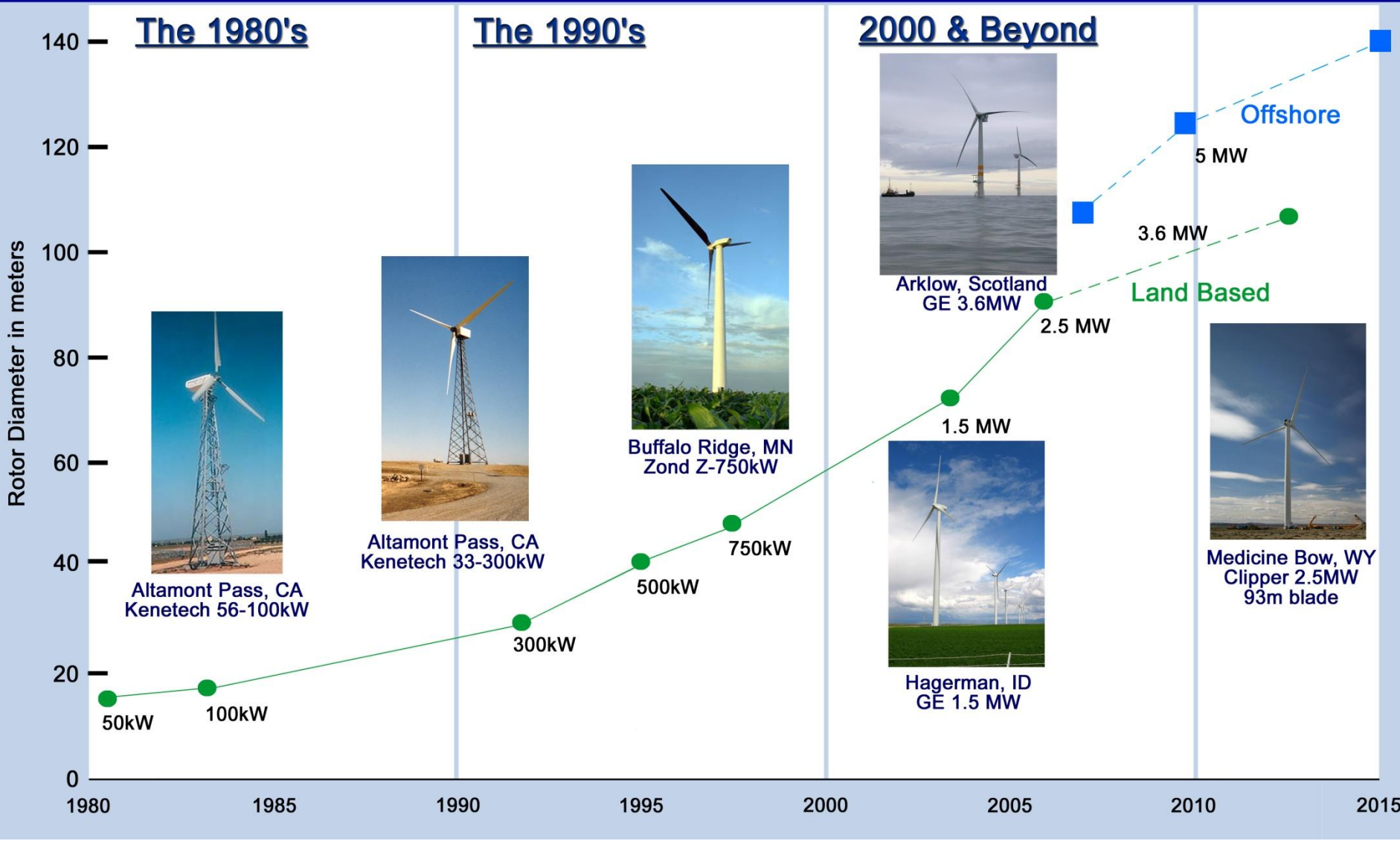
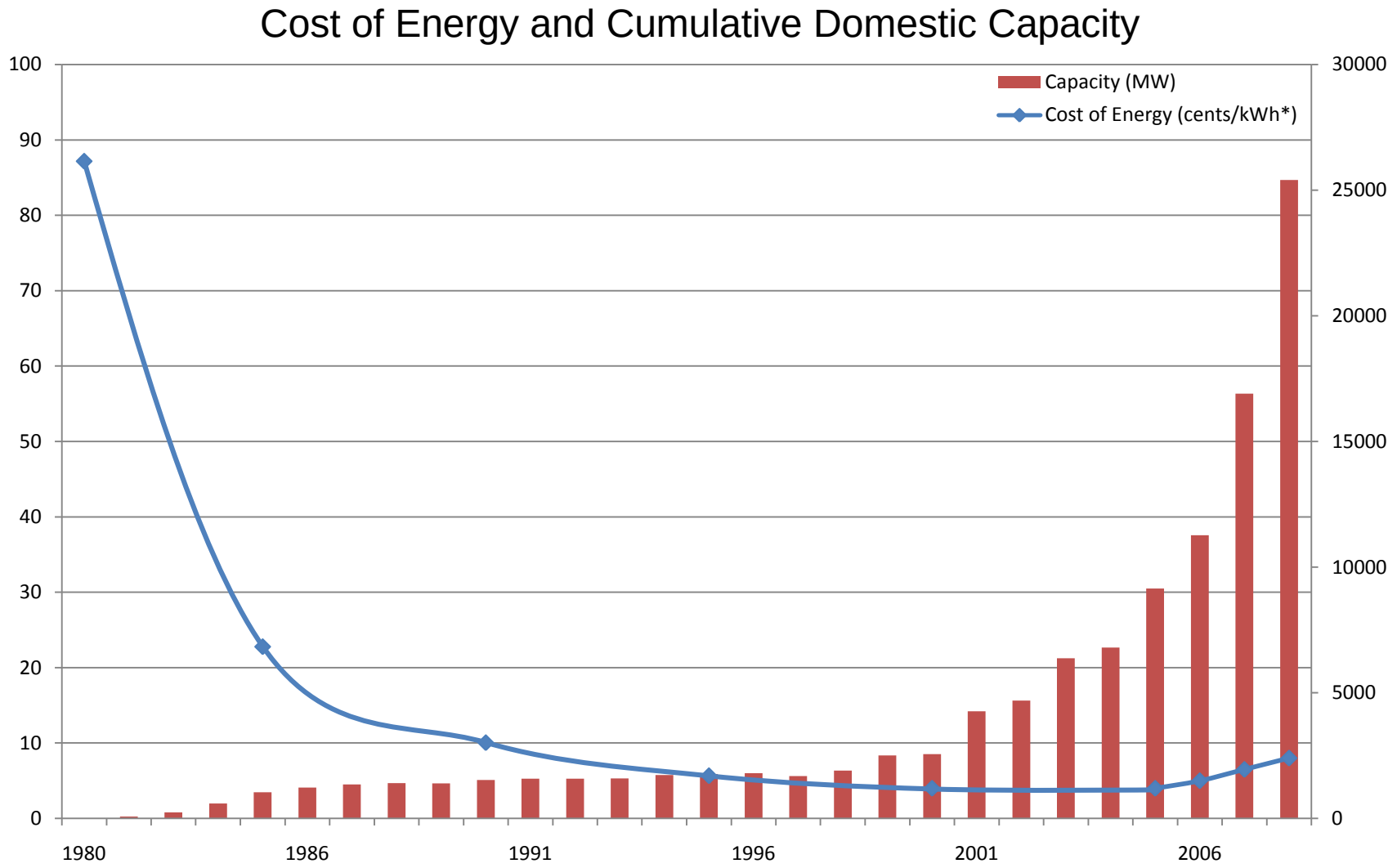
National Renewable Energy Laboratory

July 2009

Evolution of U.S. Commercial Wind Technology

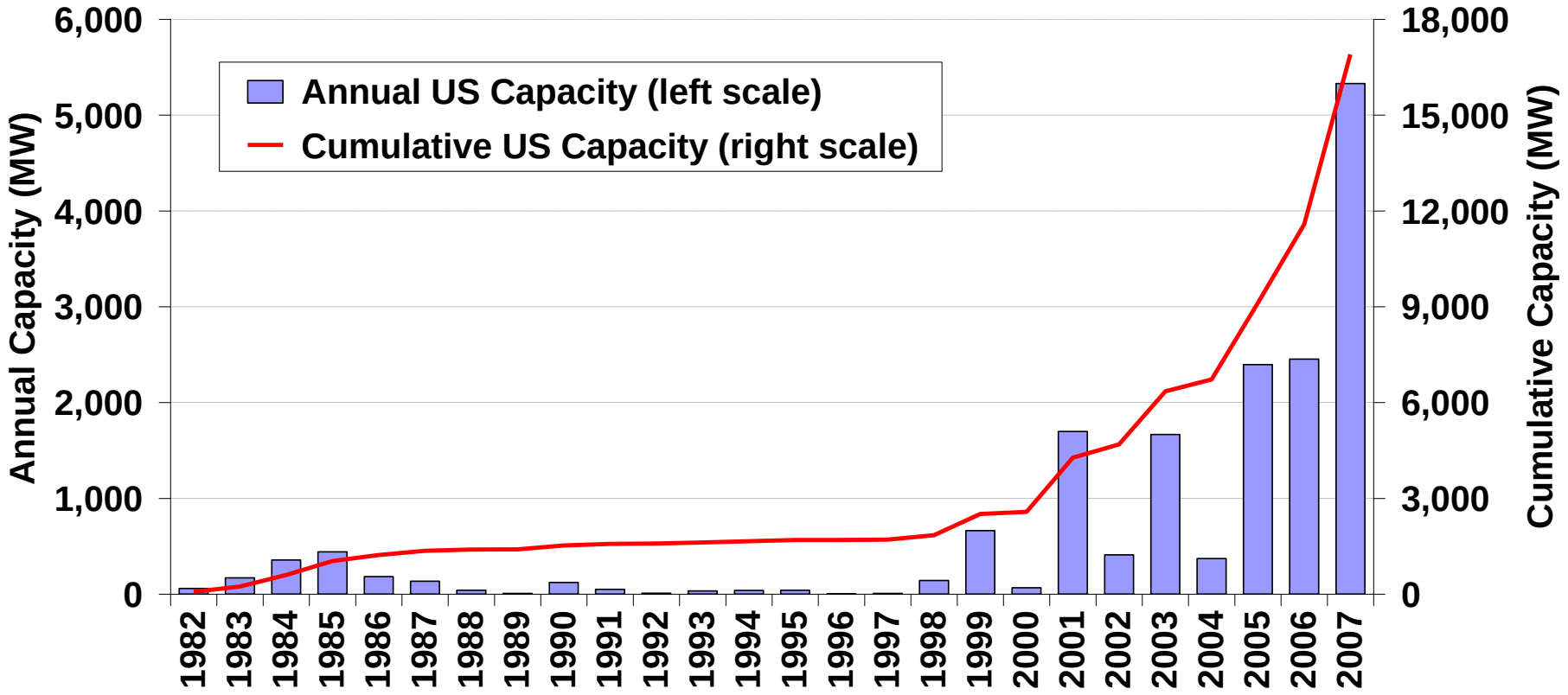


Capacity & Cost Trends



Increased Turbine Size - R&D Advances - Manufacturing Improvements

U.S. Wind Power Capacity Up 46% in 2007

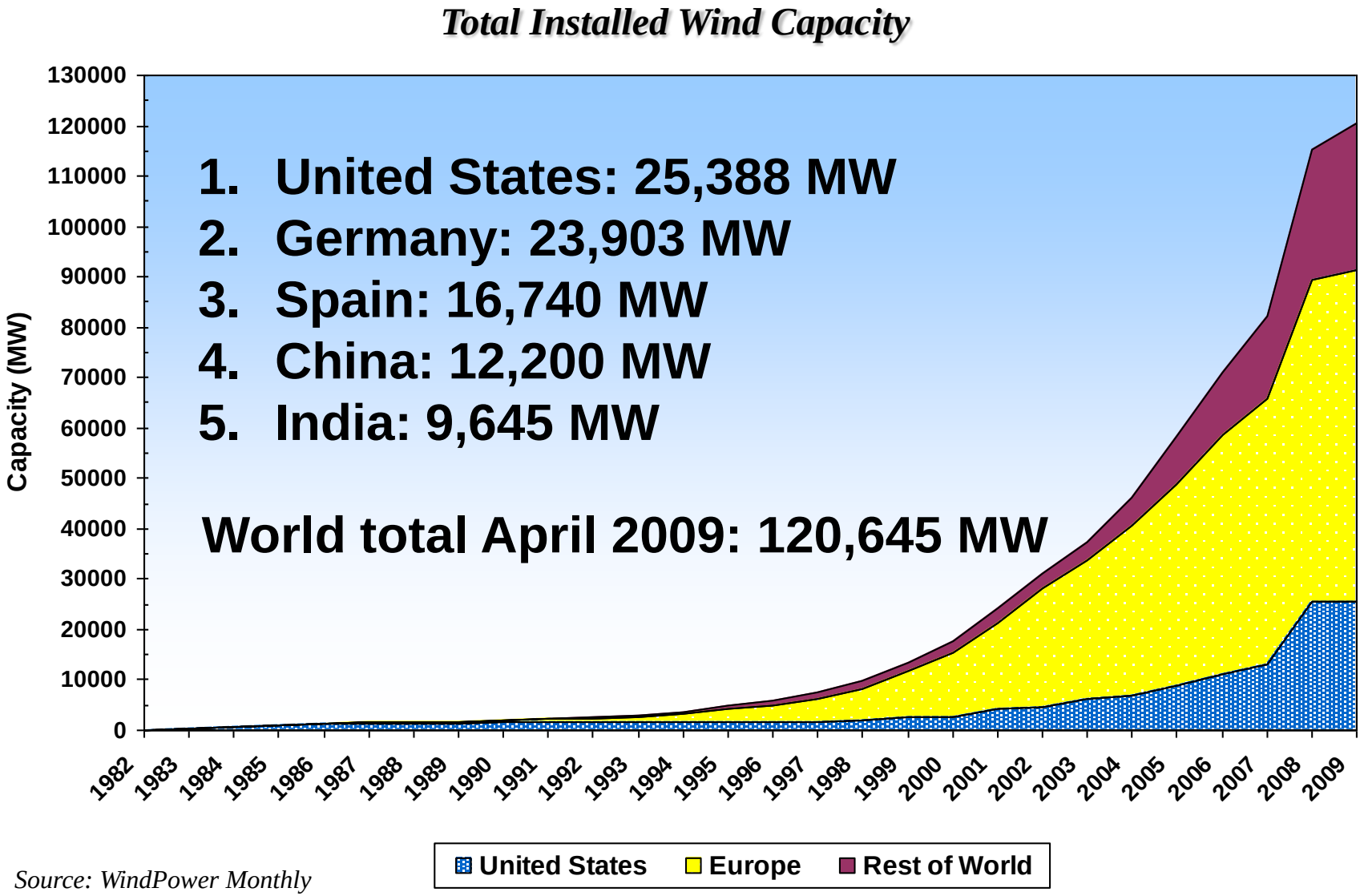


Source: AWEA

Record year for new U.S. wind capacity:

- 5,329 MW of wind added (*more than double* previous record)
- Roughly $9 billion in investment

People Want Renewable Energy!



Source: WindPower Monthly

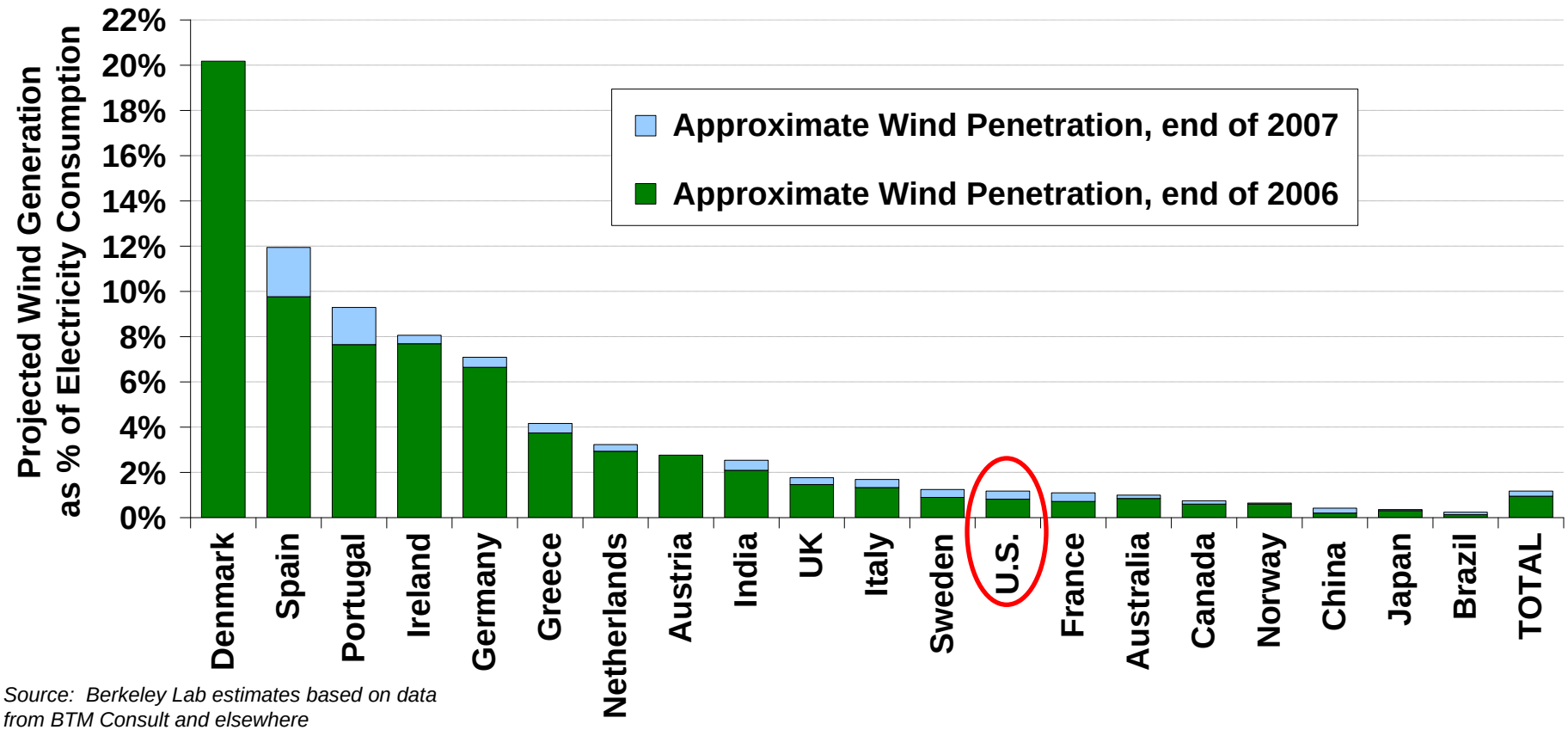
U.S. Led the World in 2007 Wind Capacity Additions; Second in Cumulative Capacity

Incremental Capacity (2007, MW)	
U.S.	**5,329**
China	3,287
Spain	3,100
Germany	1,667
India	1,617
France	888
Italy	603
Portugal	434
U.K.	427
Canada	386
Rest of World	2,138
TOTAL	**19,876**

Cumulative Capacity (end of 2007, MW)	
Germany	22,277
U.S.	**16,904**
Spain	14,714
India	7,845
China	5,875
Denmark	3,088
Italy	2,721
France	2,471
U.K.	2,394
Portugal	2,150
Rest of World	13,591
TOTAL	**94,030**

Source: BTM Consult; AWEA project database for U.S. capacity.

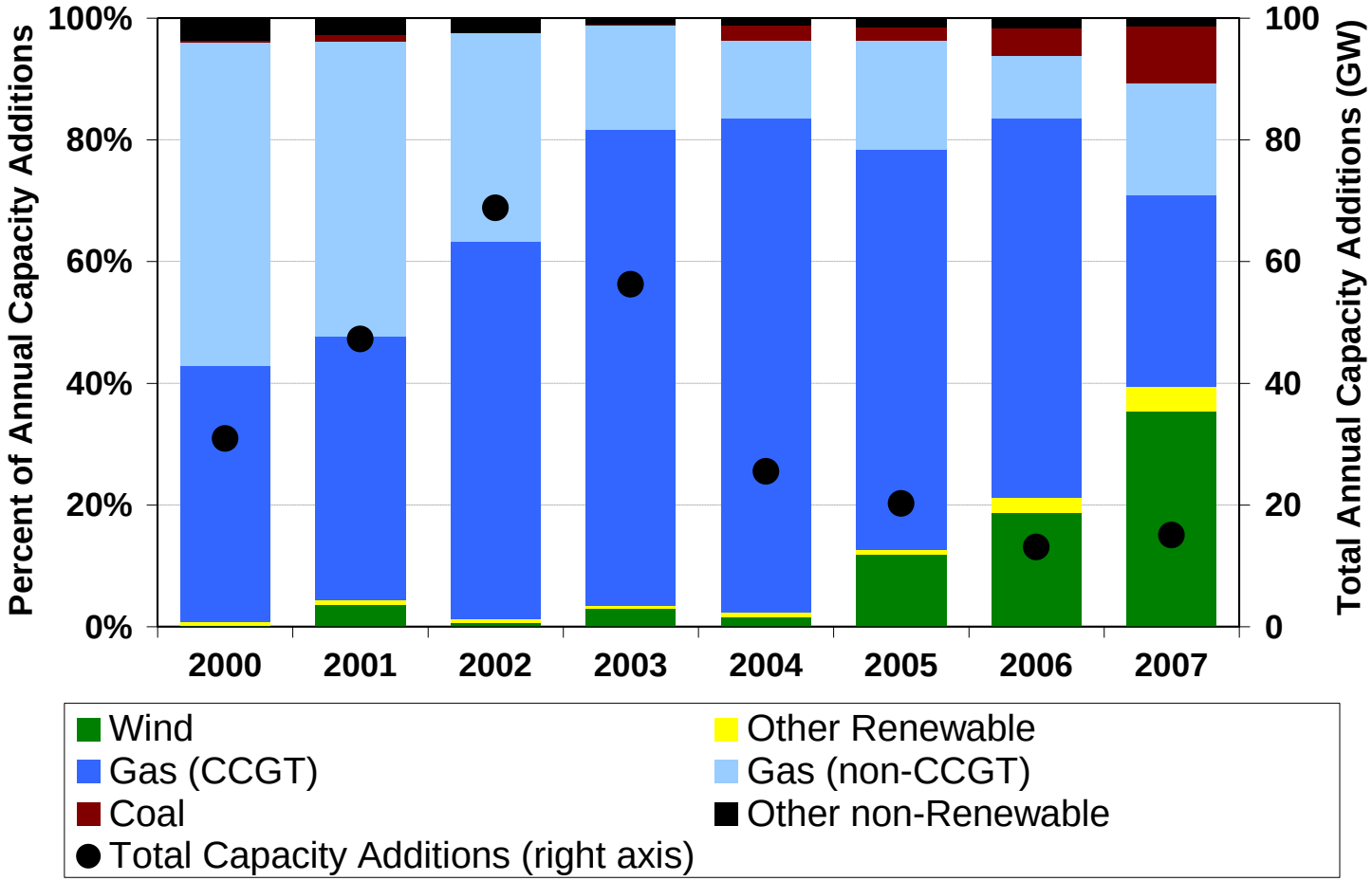
U.S Lagging Other Countries in Wind As a Percentage of Electricity Consumption



Source: Berkeley Lab estimates based on data from BTM Consult and elsewhere

Note: Figure only includes the 20 countries with the most installed wind capacity at the end of 2007

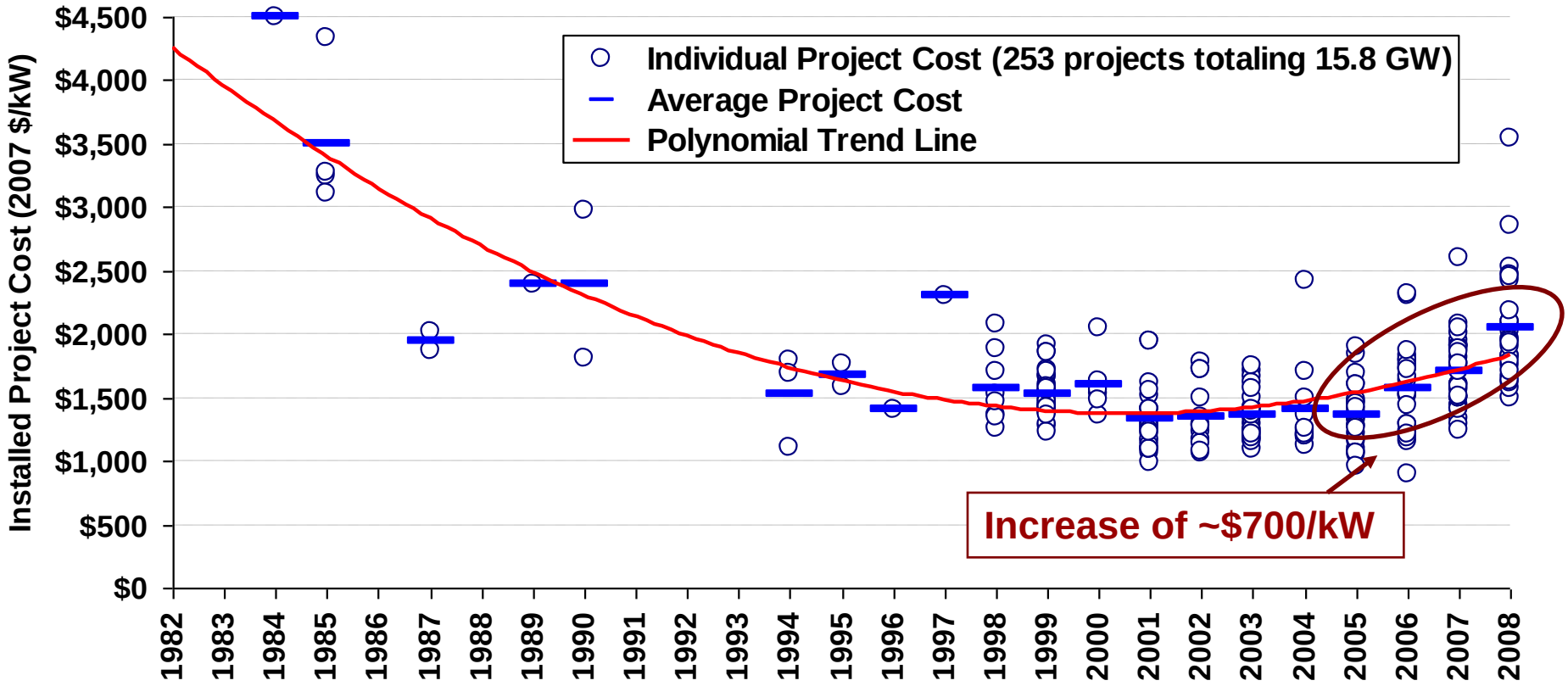
Wind Power Contributed 35% of All New Generating Capacity in the US in 2007



- Wind was the 2nd-largest resource added for the 3rd-straight year
- Up from 19% in 2006, 12% in 2005, and <4% in 2000-2004

Source: EIA, Ventyx, AWEA, IREC, Berkeley Lab

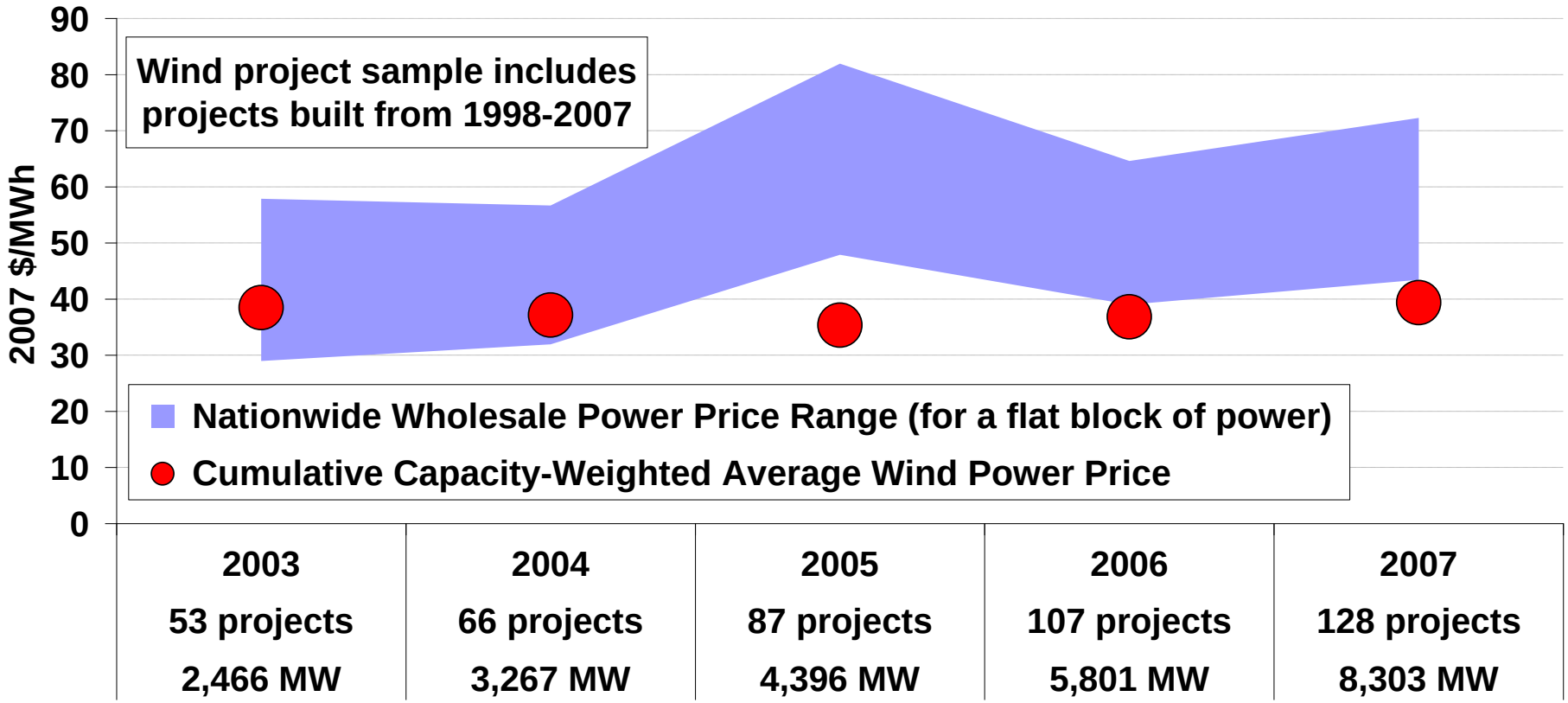
Installed Project Costs Are On the Rise, After a Long Period of Decline



Source: Berkeley Lab database (some data points suppressed to protect confidentiality)

Note: Includes 227 projects built from 1983-2007, totaling ~13 GW (77% of capacity at end of 2007); additional ~2.8 GW of projects proposed for installation in 2008

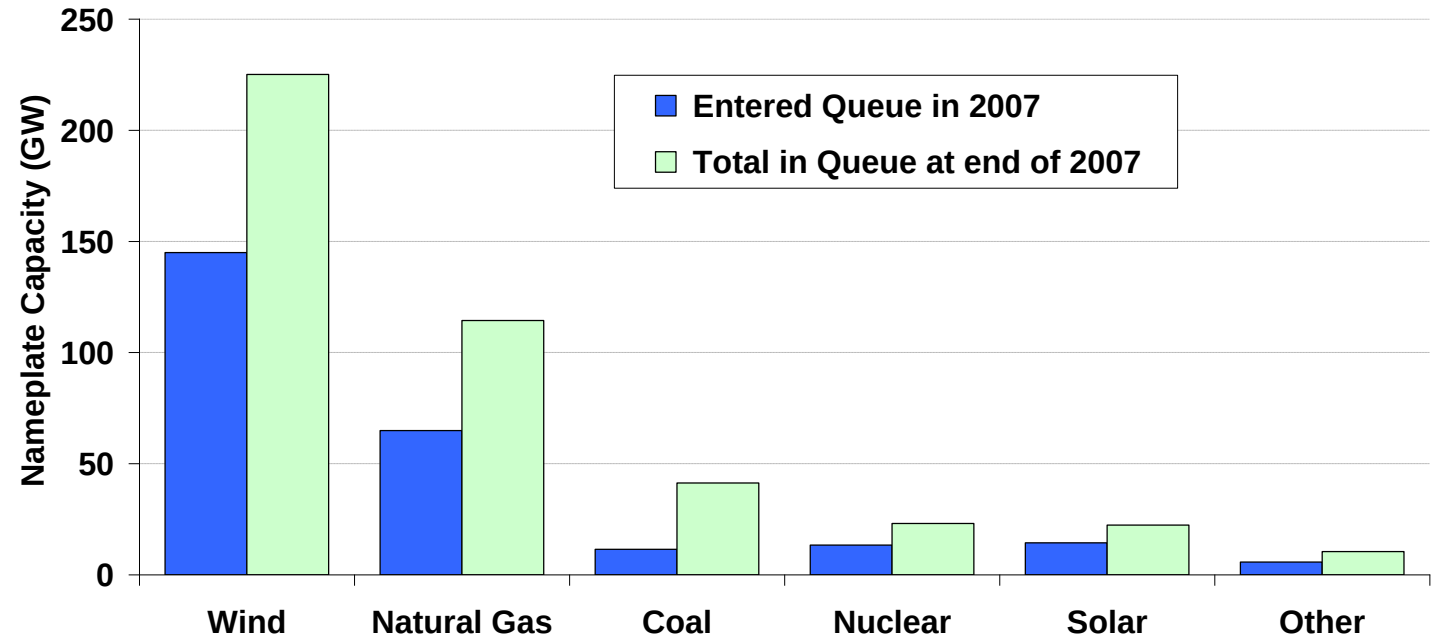
Wind Has Been Competitive with Wholesale Power Prices in Recent Years



Source: FERC 2006 and 2004 "State of the Market" reports, Berkeley Lab database, Ventyx

- Wholesale price range reflects flat block of power across 23 pricing nodes (see previous map)
- Wind prices are capacity-weighted averages from cumulative project sample

Regardless of these pricing trends, more than 225 GW of wind has applied for interconnection

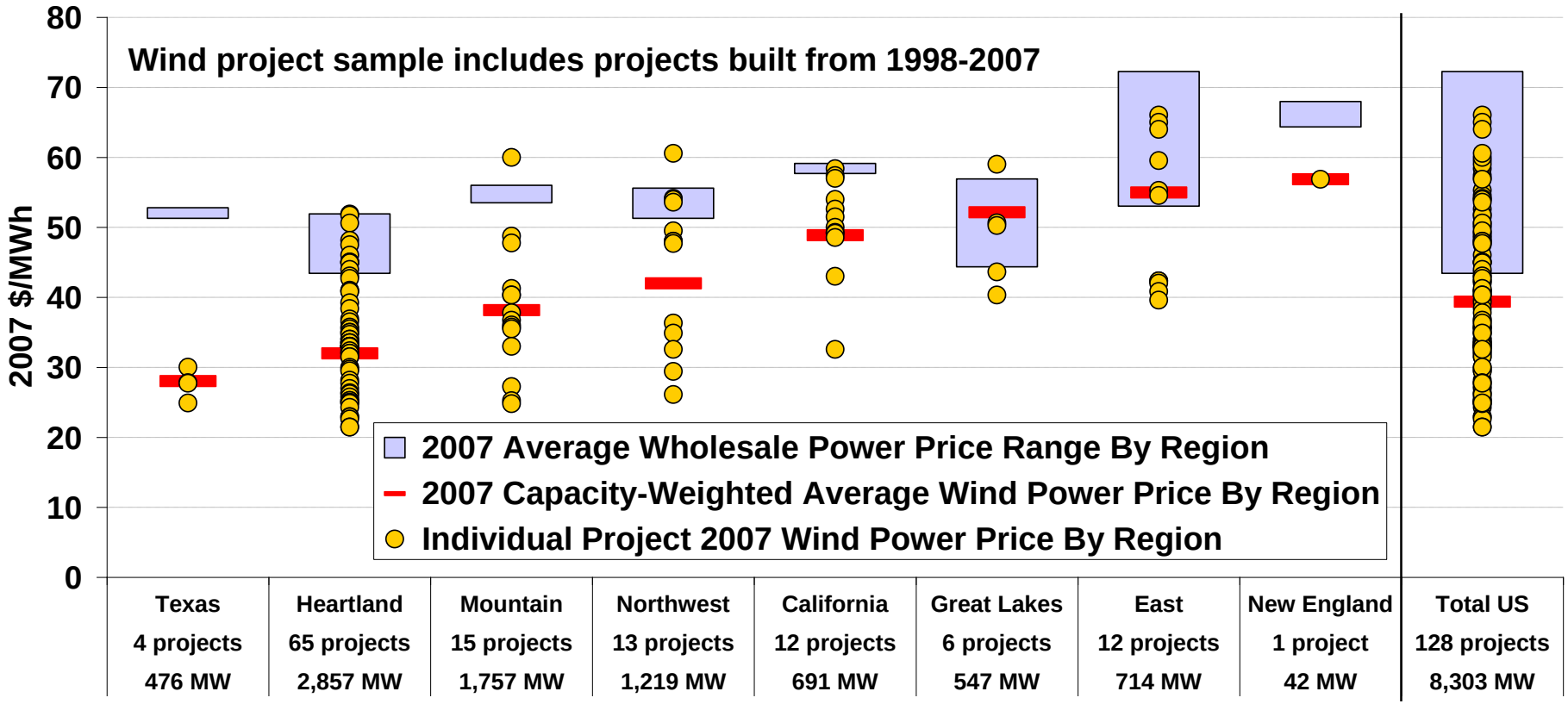


Source: Exeter Associates review of interconnection queues

Note: Figure includes data from 11 wind-relevant interconnection queues, so does not represent a truly national picture

- MISO (66 GW), ERCOT (41 GW), and PJM (35 GW) make up 2/3 of total
- Twice as much wind as next largest resource (natural gas) in these queues
- ***Not all of the capacity will be built, but demonstrates enormous interest***

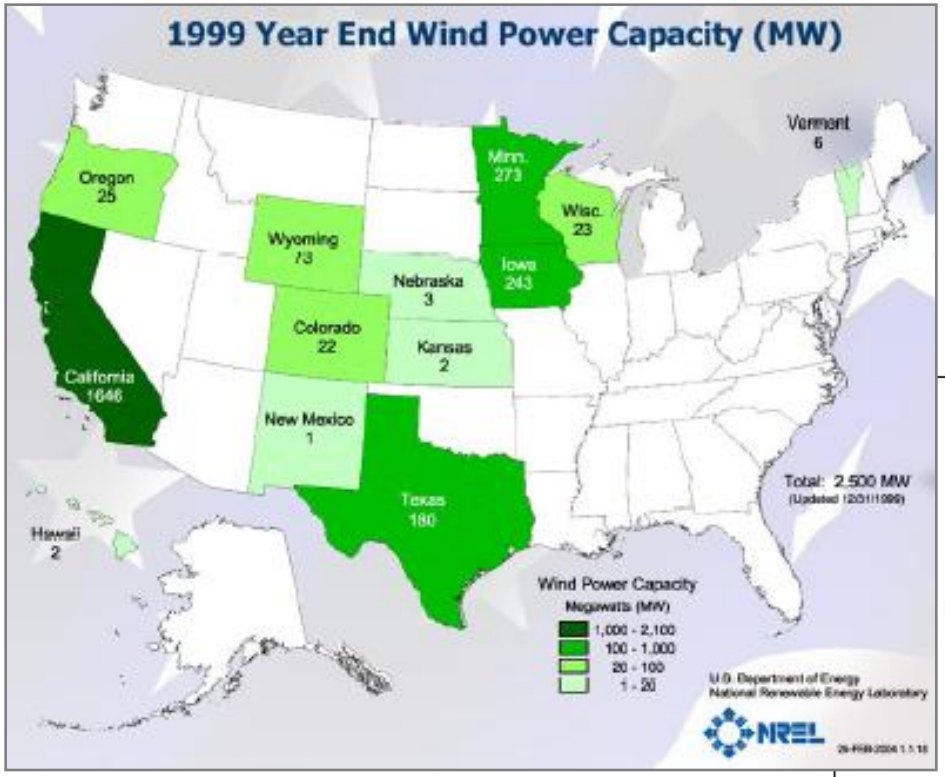
Wind Built After 1997 Was Competitive with Wholesale Prices in Most Regions in 2007

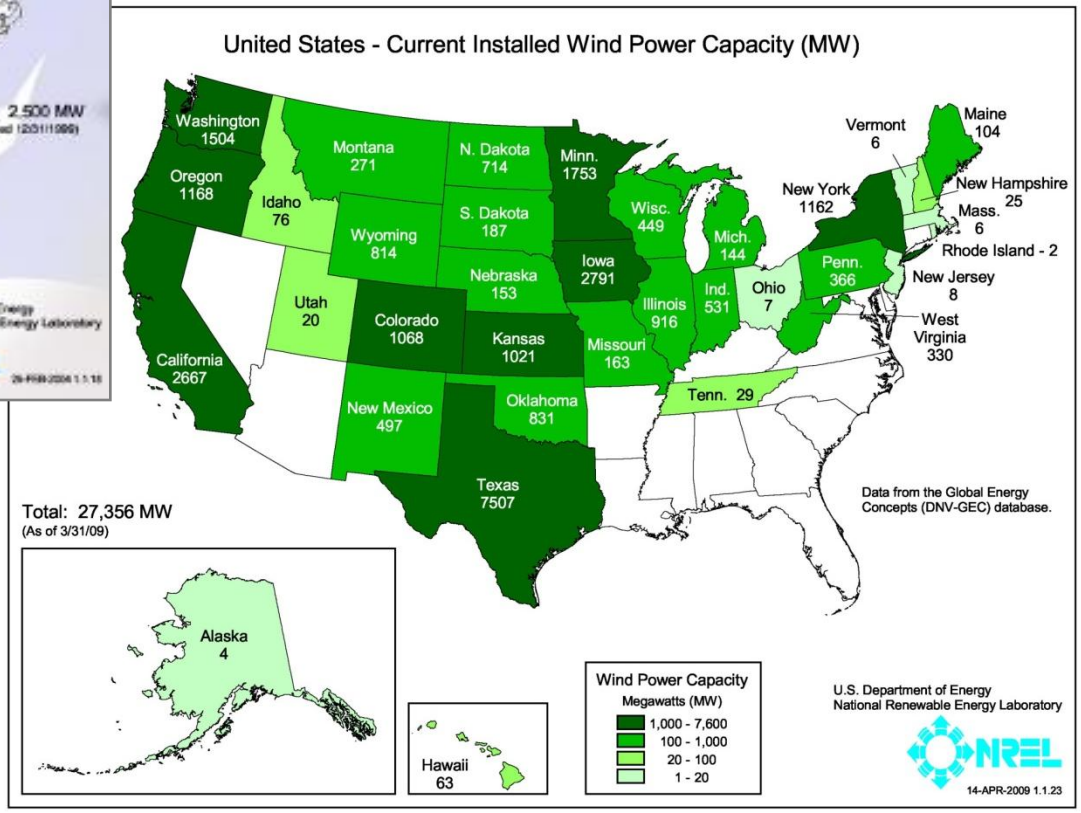


Source: Berkeley Lab database, Ventyx

Note: Even within a region there are a range of wholesale power prices because multiple wholesale price hubs exist in each area (see earlier map)

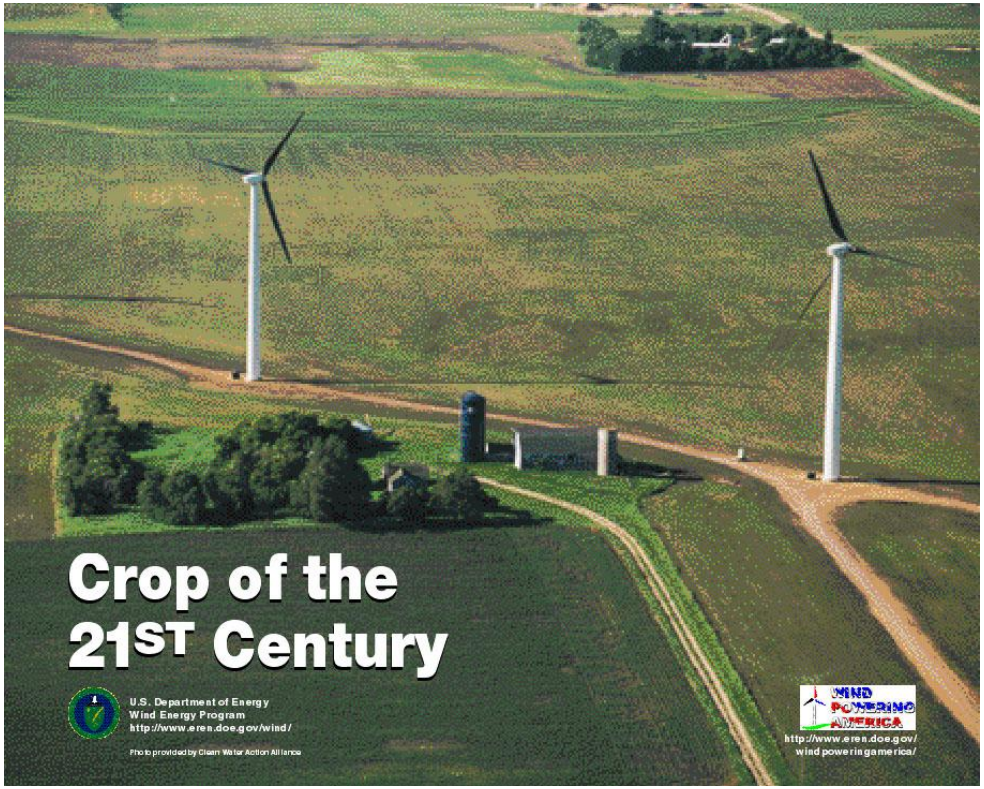
Installed Wind Capacities
(‘99 – March ‘08)



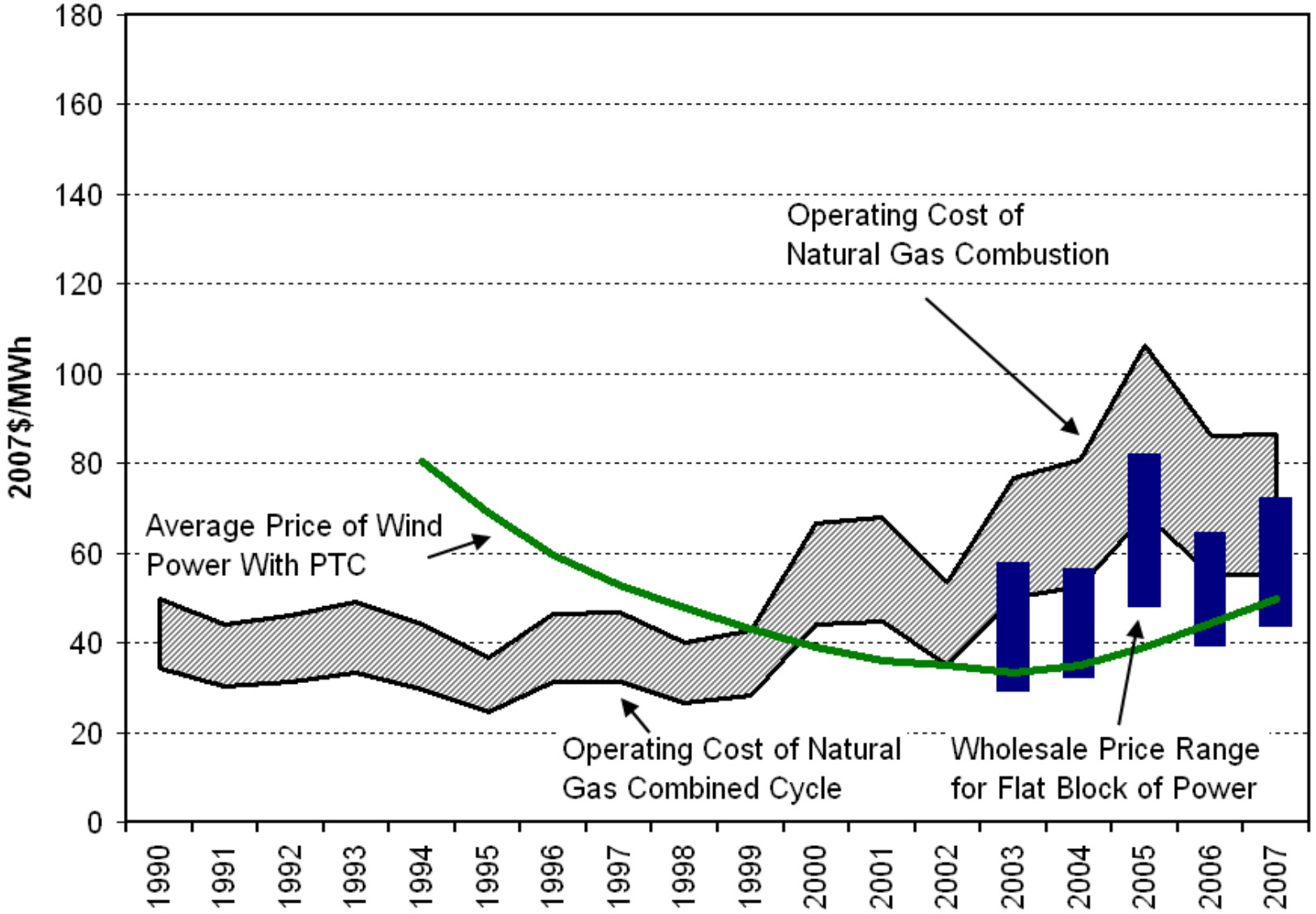


Drivers for Wind Power

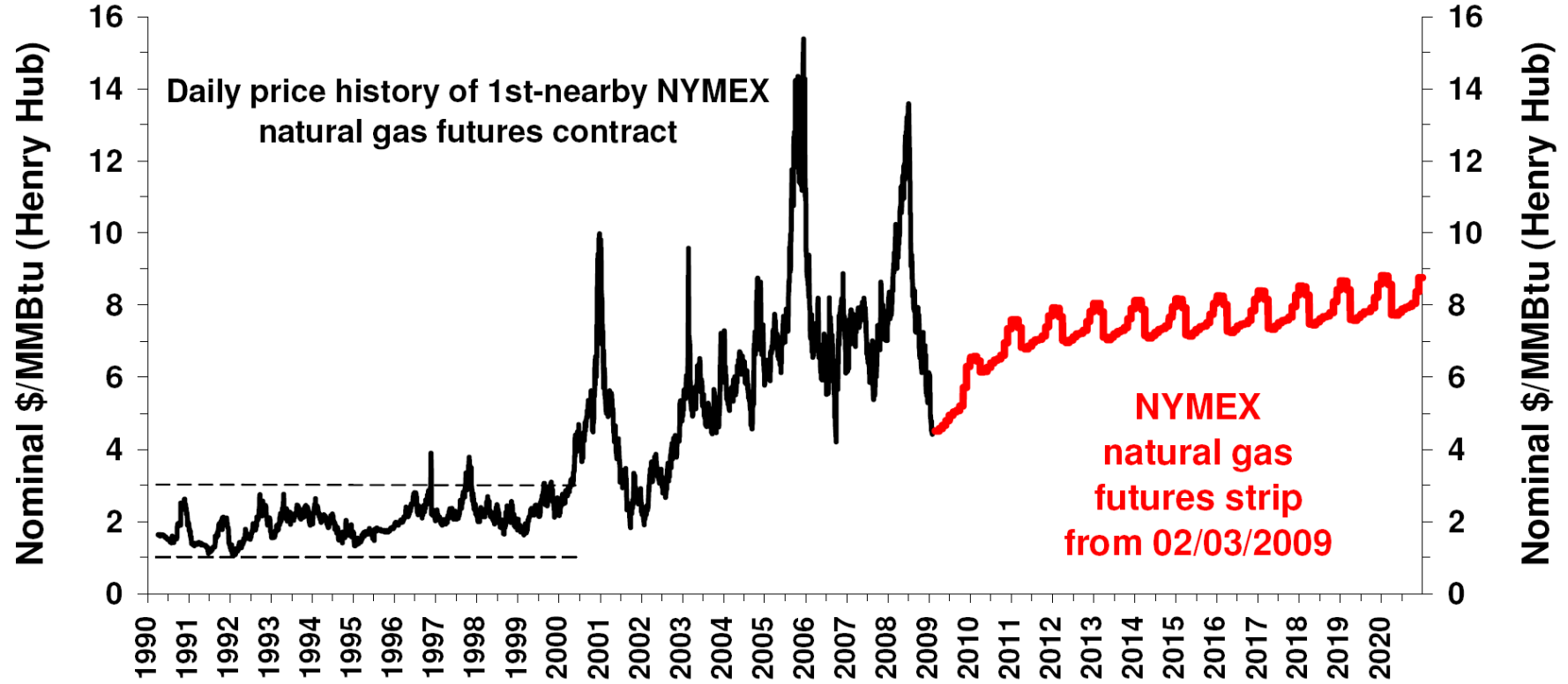
- Declining Wind Costs
- Fuel Price Uncertainty
- Federal and State Policies
- Economic Development
- Public Support
- Green Power
- Energy Security
- Carbon Risk



Comparative Generation Costs

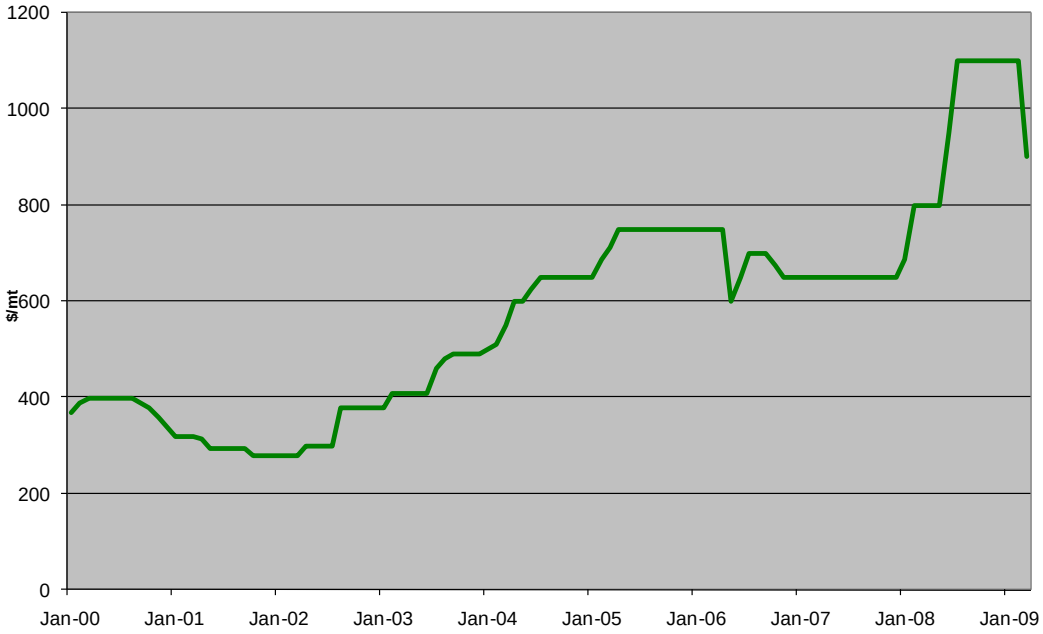


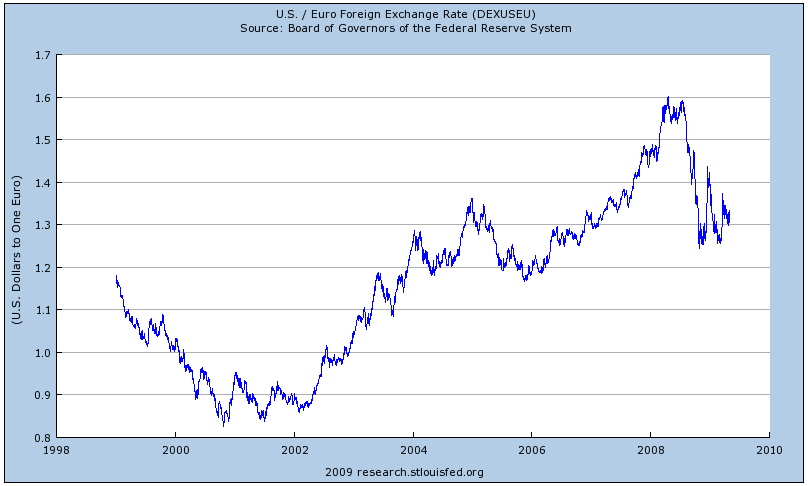
Natural Gas – Historic Prices



Source: LBNL

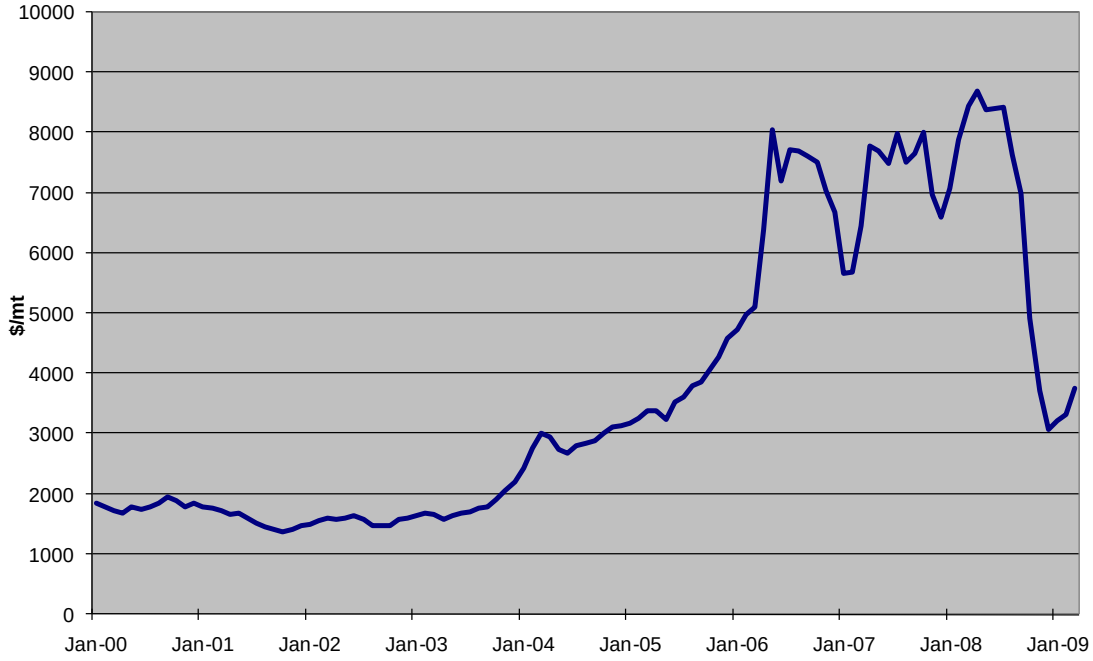
Historic Steel Prices - Cold Rolled





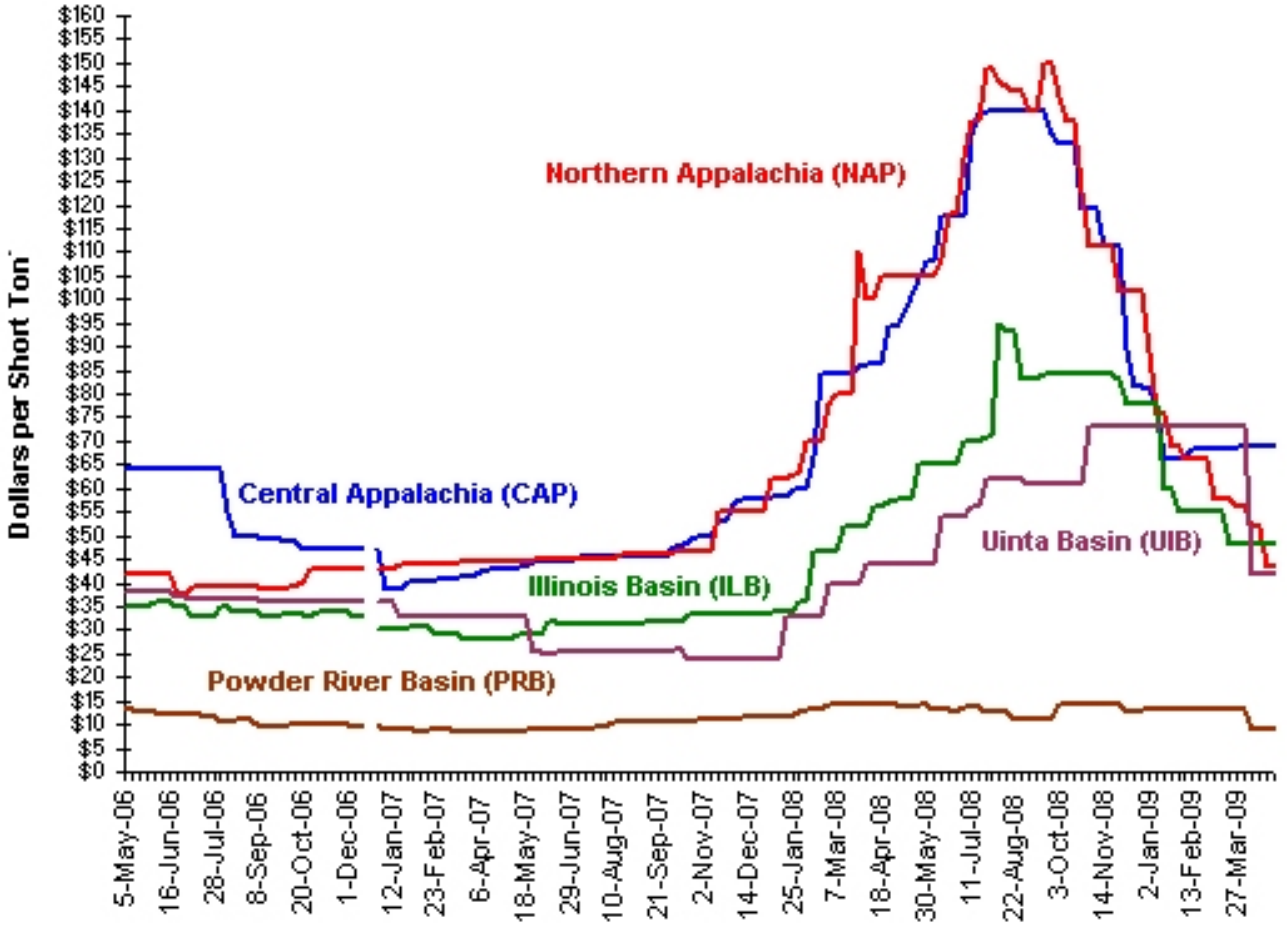
Wind Cost Drivers

Historic Copper Prices



Copper & Steel Price Source: World Bank, Commodity Price Data

Historical Coal Prices

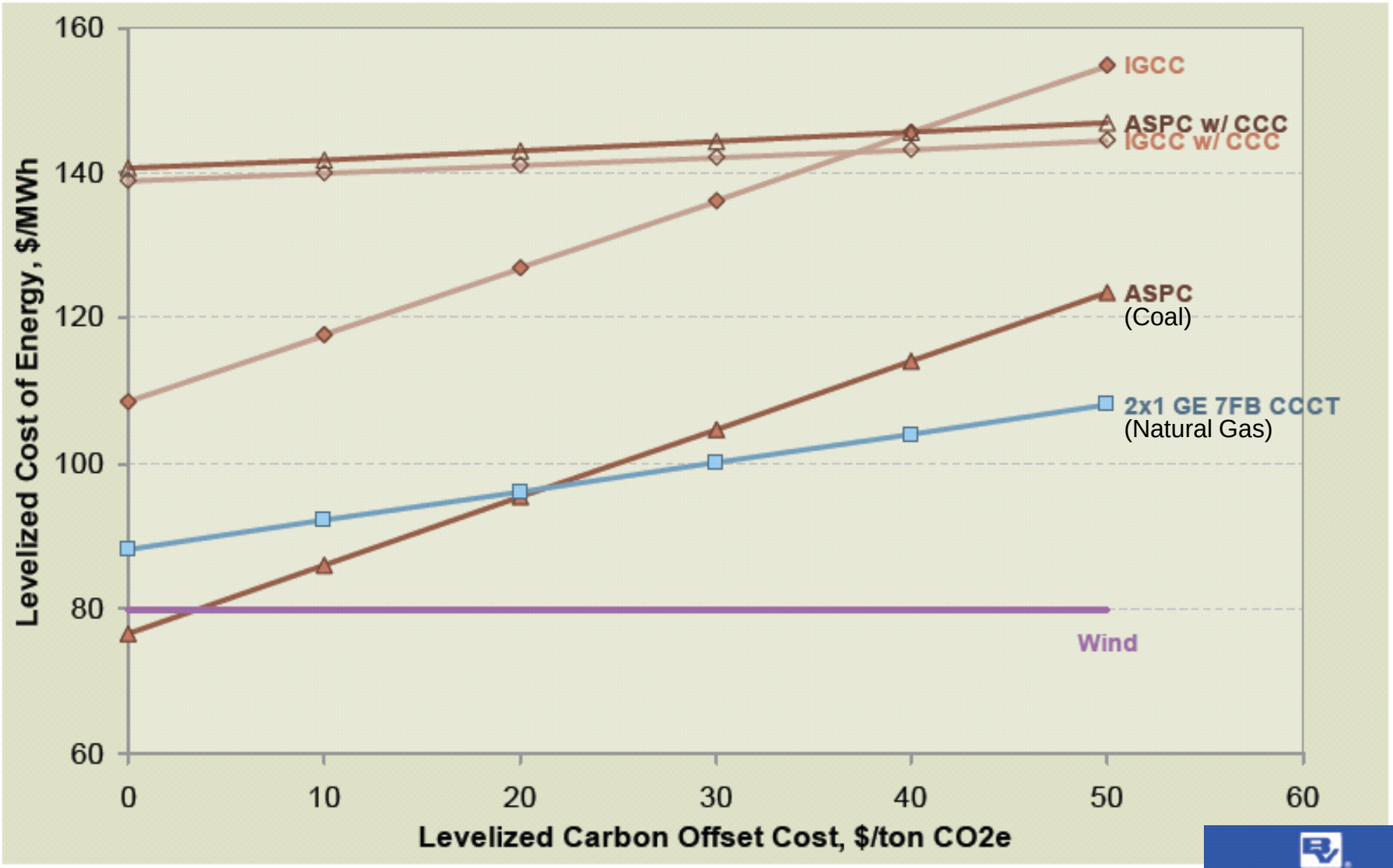


Key to Coal Commodities by Region

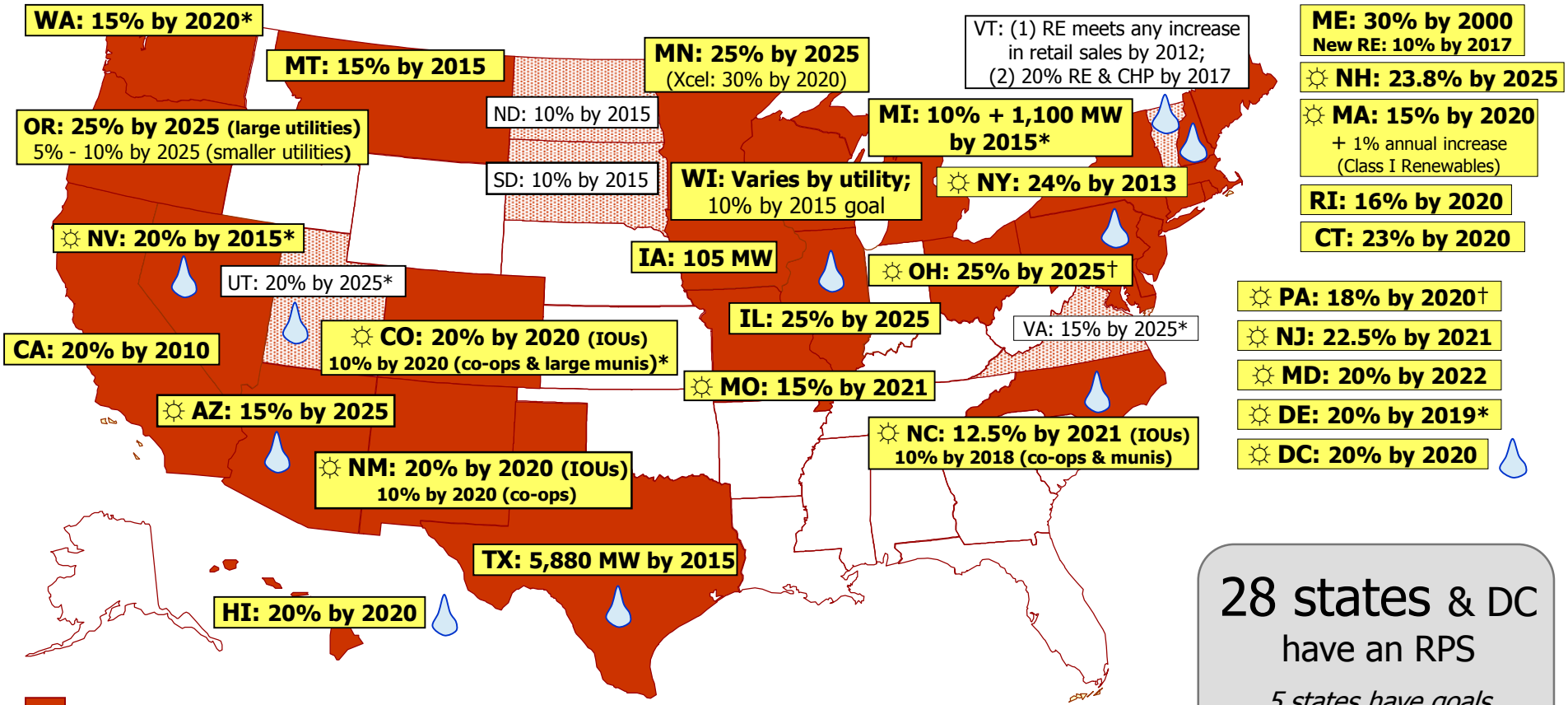
Central Appalachia:	Big Sandy/Kanawha 12,500 Btu, 1.2 lb SO2/mmBtu	Powder River Basin:	8,800 Btu, 0.8 lb SO2/mmBtu
Northern Appalachia	Pittsburgh Seam 13,000 Btu, <3.0 lb SO2/mmBtu	Uinta Basin in Colo.:	11,700 Btu, 0.8 lb SO2/mmBtu
Illinois Basin:	11,800 Btu, 5.0 lb SO2/mmBtu		

Source: EIA

CO_2 prices significantly increase the cost of coal



Renewables Portfolio Standards



28 states & DC have an RPS

5 states have goals

State renewable portfolio standard

State renewable portfolio goal

Solar water heating eligible

Minimum solar or customer-sited requirement

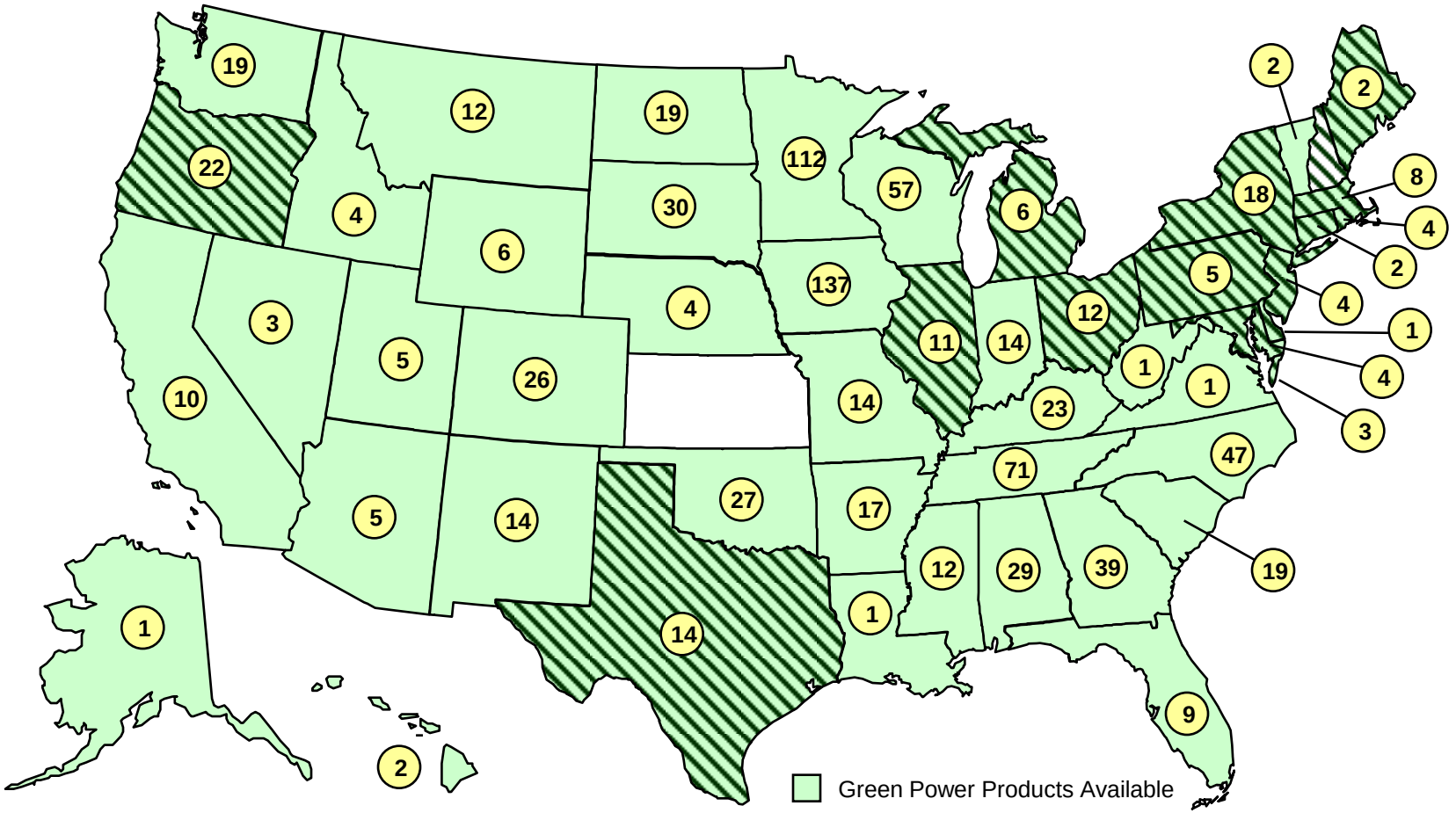
* Extra credit for solar or customer-sited renewables

† Includes separate tier of non-renewable alternative resources

DSIRE: www.dsireusa.org

May 2009

States with Green Power Programs



Source: National Renewable Energy Laboratory (September 2008)

Wind Energy Investors

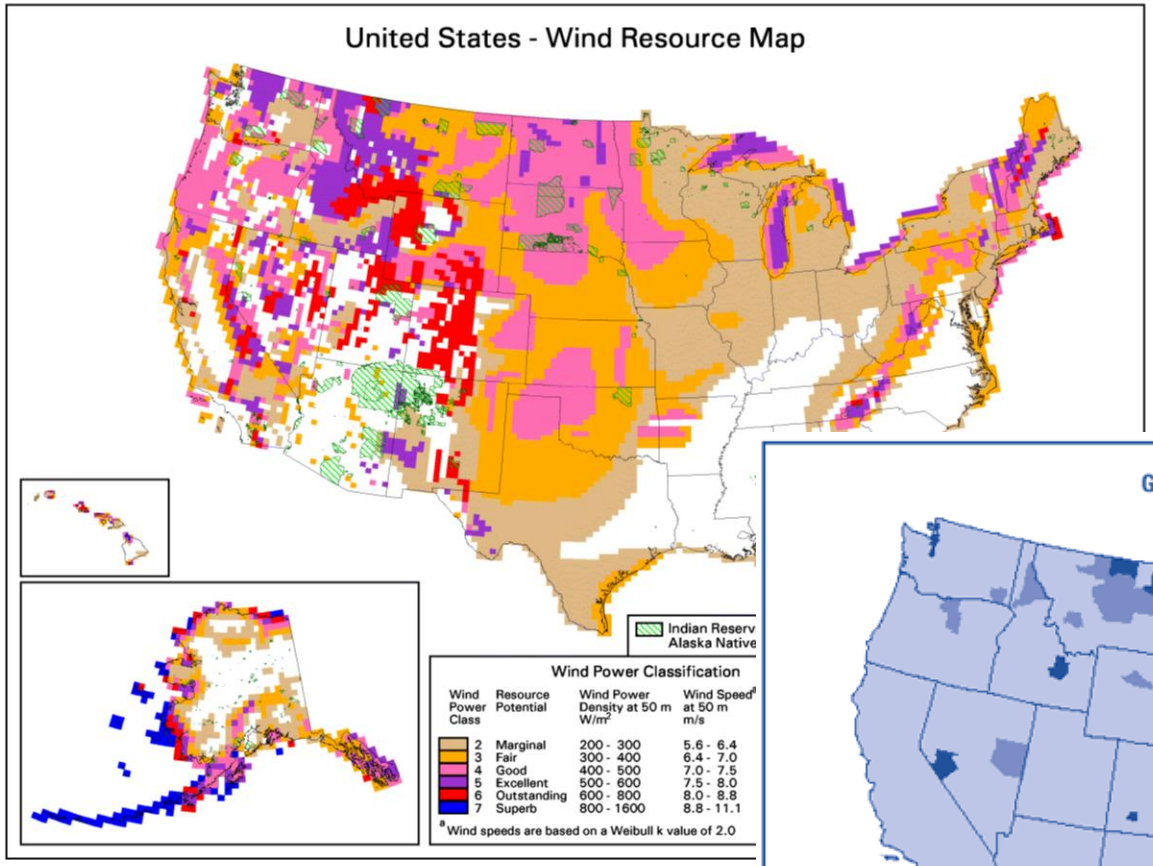


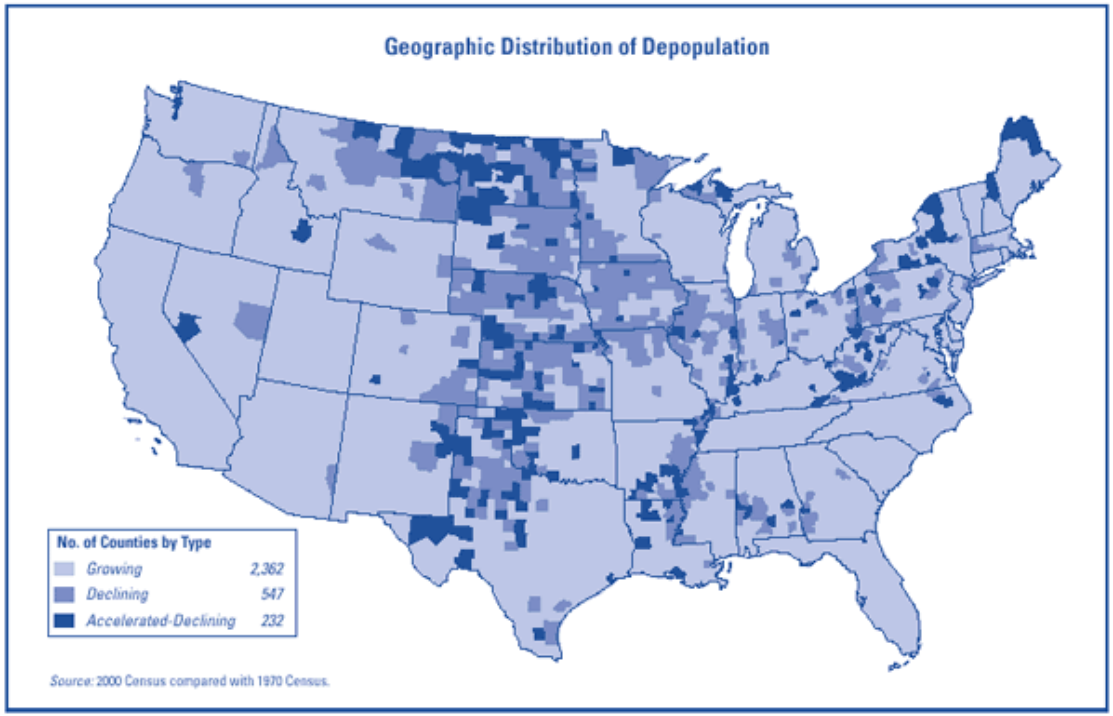
BP Solar

JOHN DEERE



Windy Rural Areas Need Economic Development





Economic Development Impacts

- **Land Lease Payments**: 2-3% of gross revenue $2500-4000/MW/year
- **Local property tax** revenue: ranges widely - $300K-1700K/yr per 100MW
- 100-200 **jobs**/100MW during construction
- 6-10 permanent O&M **jobs** per 100 MW
- Local construction and service industry: concrete, towers usually done locally

Direct jobs and parts during construction

Truck drivers,
crane operators

Wind Turbine Components

Earth moving, cement pouring

Management and support

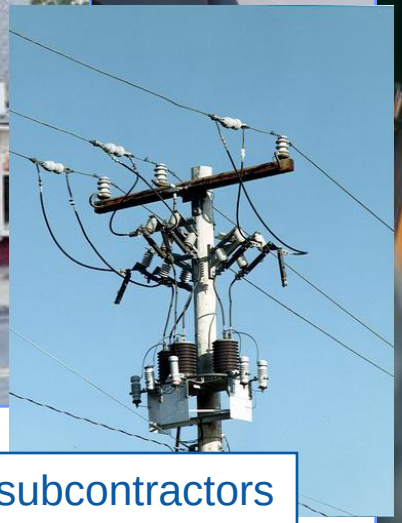
Construction

Direct wind project jobs during **operations**

Operations and maintenance, management

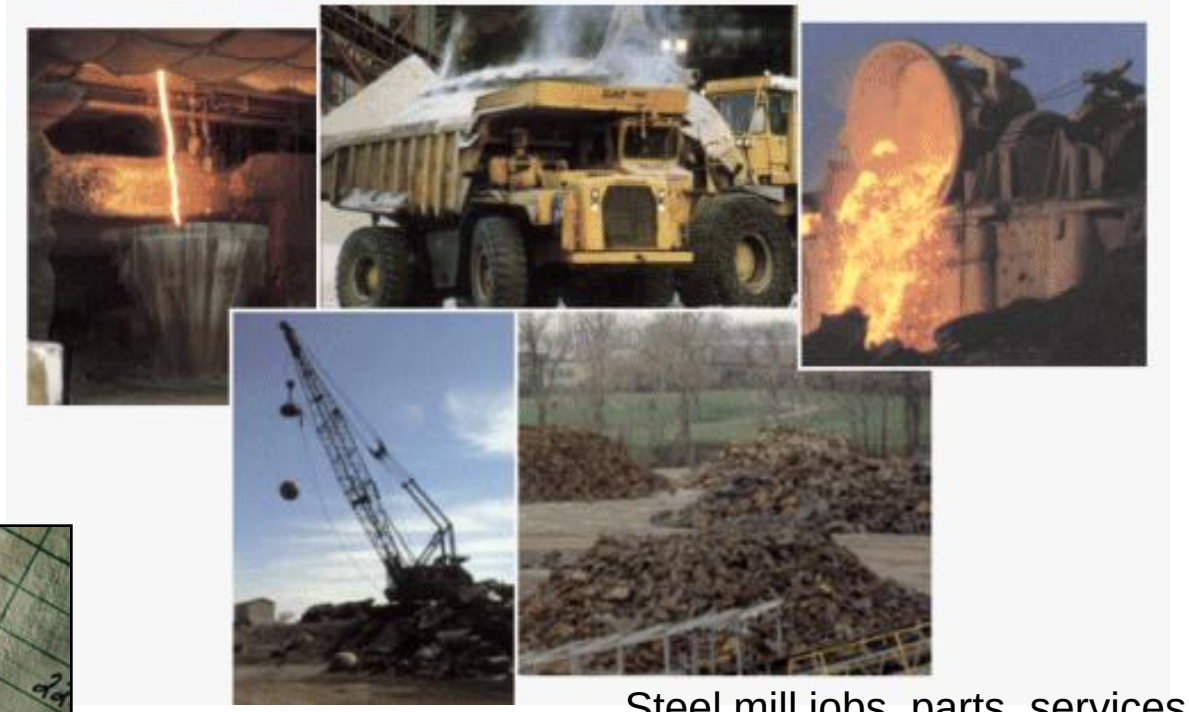
Landowner royalties

Parts and materials purchased



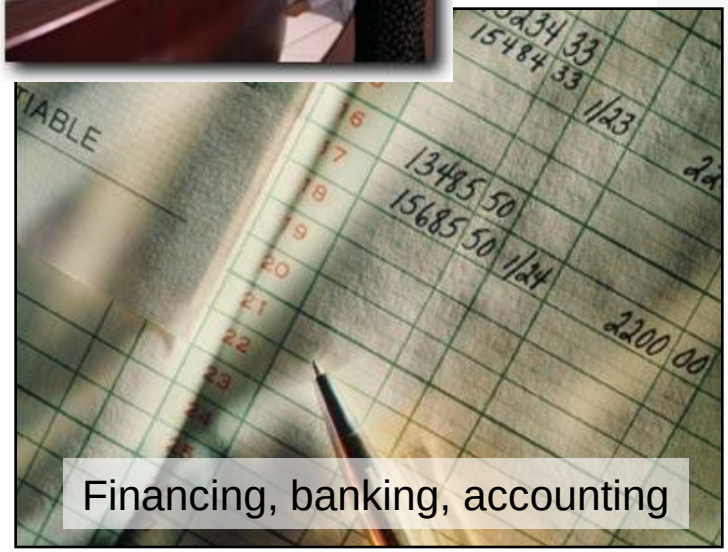
Utility services and subcontractors

Indirect jobs, services, materials



Steel mill jobs, parts, services

Photos: E.C.Levy, Inc, Detroit, MI



Wind subcomponent manufacturing and sales

Induced jobs, services, materials

Child care, grocery store, clothing, other retail, public transit, new cars, restaurants, medical services

Wind Energy's Economic impacts

On-site direct, off-site direct, Indirect, Induced

Wind energy's economic "ripple effect"

Direct Impacts

On-site	Off-site
Construction workers Management Administrative support	Boom truck & management, gas and gas station workers, blades and towers & workers
Cement truck drivers, road crews, maintenance workers	Hardware store purchases and workers, spare parts and their suppliers

Indirect Impacts

These are jobs in and payments made to supporting businesses, such as bankers financing the construction, contractor, manufacturers and equipment suppliers of subcomponents.

Induced Impacts

These jobs and earnings result from the spending by people directly and indirectly supported by the project, including benefits to grocery store clerks, retail salespeople and child care providers.

Case Study: Iowa

240-MW Iowa wind project

- $640,000/yr in lease payments to farmers ($2,000/turbine/yr)
- $2M/yr in property taxes
- $5.5M/yr in O&M income
- **40 long-term O&M jobs**
- **200 short-term construction jobs**
- Doesn't include multiplier effect

South Dakota Wind Energy Center

- 40.5 MW (1.5-MW turbines)
- Landowner payments: $3,500-$4,000/year
- 100 – 125 workers during peak construction
- 3 fulltime O&M positions
- **Property taxes: $220,000/year**
- Sales and use tax: $1.2 million payable in 2003
- Located near Highmore, SD (population 808)
- Owned by FPL Energy
- Constructed in 2003

Peetz Table Wind Energy Center, CO

- 400.5 MW (1.5-MW turbines)
- Landowner payments: $2 million/year, $65 million over 30-year period
- 300 – 350 workers during peak construction (80% local)
- **16 – 18 O&M positions**
- Total annual tax payments: $2.3 million/year (10% of total county budget); $70 million over 30 years
- Located near Peetz, CO
- Owned by FPL Energy
- Constructed in 2007

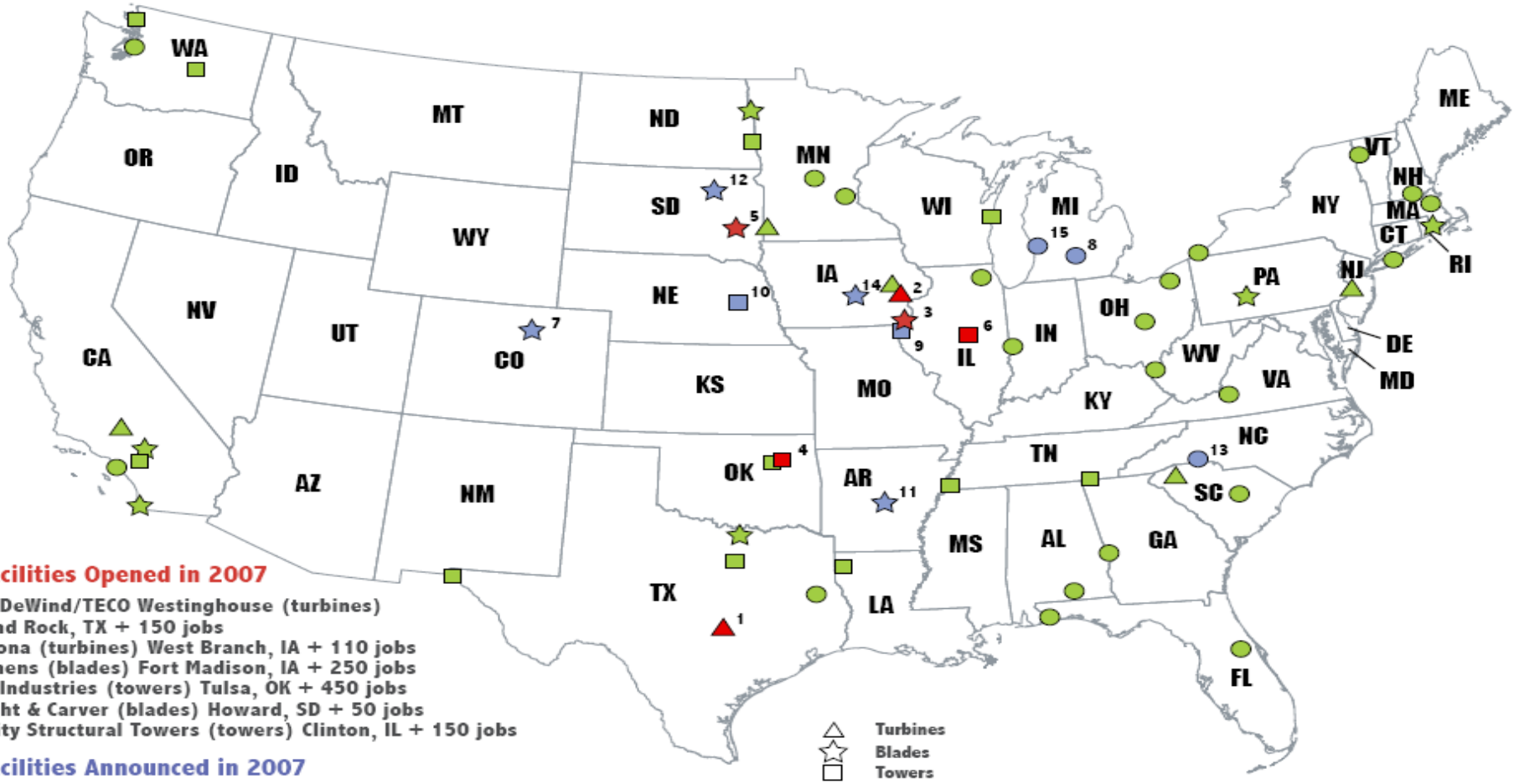
Weatherford Wind Energy Center, OK

- 147 MW (1.5-MW turbines)
- **Landowner payments: $300,000 in annual lease payments**
- 150 workers during peak construction
- 6 fulltime O&M positions
- Property taxes: $17 million over 20 years
- Sawartzky Construction received $300,000 in revenue from the project
- Owned by FPL Energy
- Constructed in 2005

Wyoming Wind Energy Center

- 144 MW (1800-kW turbines)
- Landowner payments: $18 million over the life of the project
- 175 workers during peak construction (25% local)
- 8 fulltime O&M positions
- Property taxes: $1 million (2006/7)
- **50 Wyoming companies subcontracted during the construction period**
- Located in Uinta County, WY (population 20,213)
- Owned by FPL Energy
- Constructed in 2003

Soaring Demand Spurs Expansion of U.S. Wind Turbine Manufacturing



New Facilities Opened in 2007

1. CTC-DeWind/TECO Westinghouse (turbines) Round Rock, TX + 150 jobs
2. Acciona (turbines) West Branch, IA + 110 jobs
3. Siemens (blades) Fort Madison, IA + 250 jobs
4. DMI Industries (towers) Tulsa, OK + 450 jobs
5. Knight & Carver (blades) Howard, SD + 50 jobs
6. Trinity Structural Towers (towers) Clinton, IL + 150 jobs

New Facilities Announced in 2007

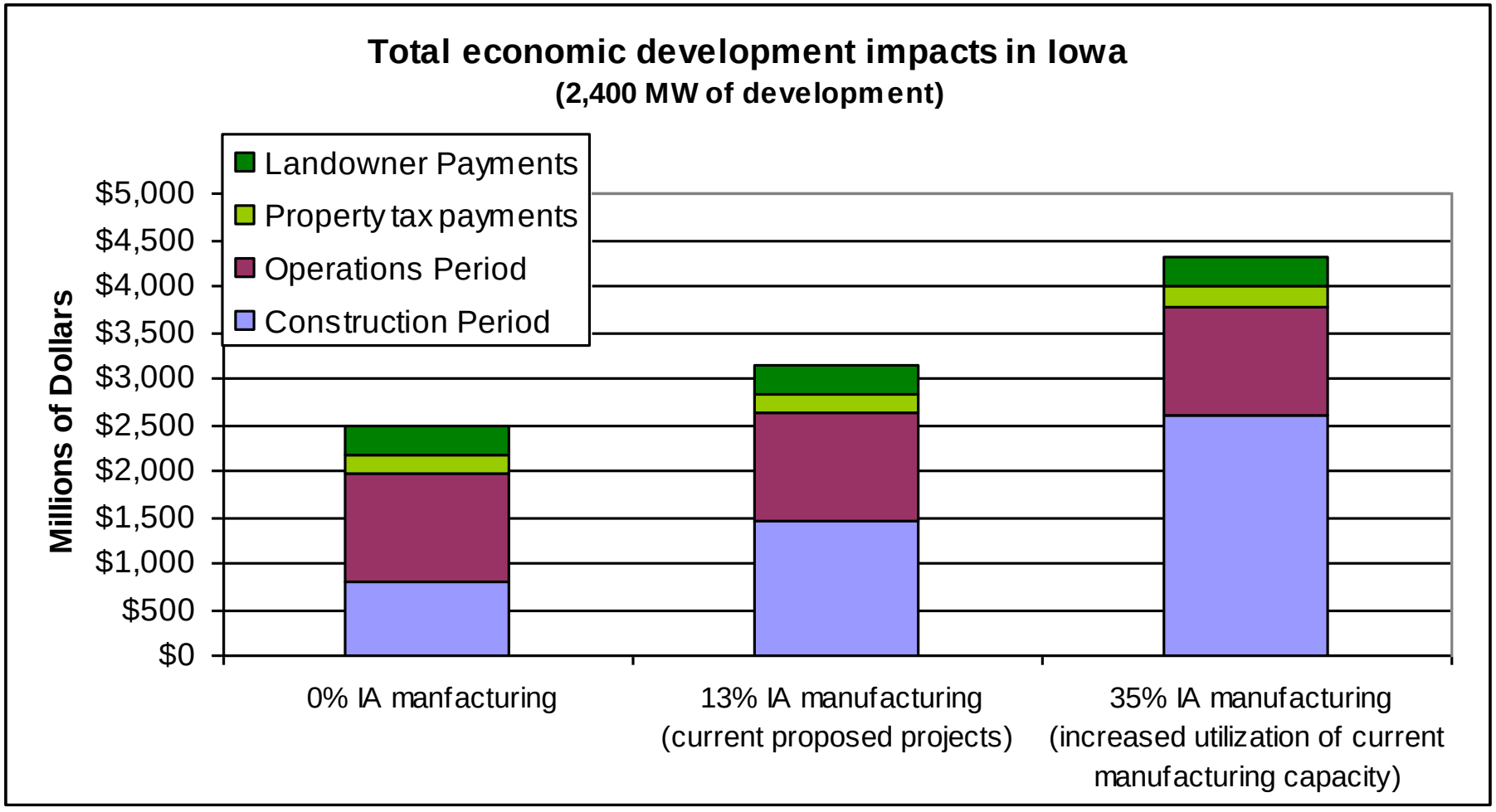
7. Vestas (blades) Windsor, CO + 650 jobs
8. Dowding Industries (turbine components) Eaton Rapids, MI + 200 jobs
9. Hendricks Industries (towers) Keokuk, IA + 350 jobs
10. Katana Summit (towers) Columbus, NE + 120 jobs
11. LM Glasfiber (blades) Little Rock, AR + 1,000 jobs
12. Molded Fiberglass (blades) Aberdeen, SD + 750 jobs
13. PPG Industries (fiberglass) Shelby, NC + not available
14. TPI Composites (blades) Newton, IA + 500 jobs
15. Genzink Steel (nacelles) Holland, MI + 10 jobs

Note: Map is not intended to be exhaustive

Figure includes wind turbine and component manufacturing facilities, as well as other supply chain facilities, and excludes corporate headquarters and service-oriented facilities. The facilities highlighted here are not intended to be exhaustive. Those facilities designated as "turbines" may include turbine assembly as well as component manufacture including, in some cases, towers and blades.

This map was created by The National Renewable Energy Laboratory for the U.S. Department of Energy April 16, 2008

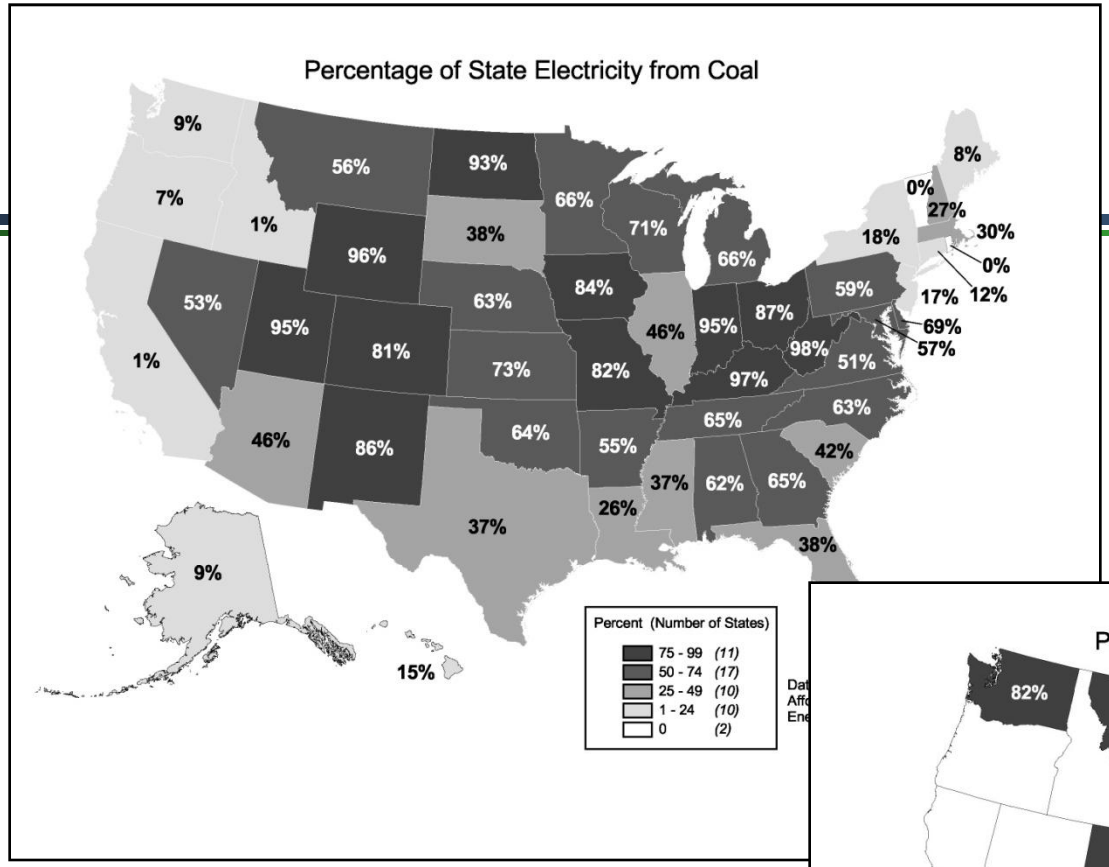
Manufacturing and Economic Development

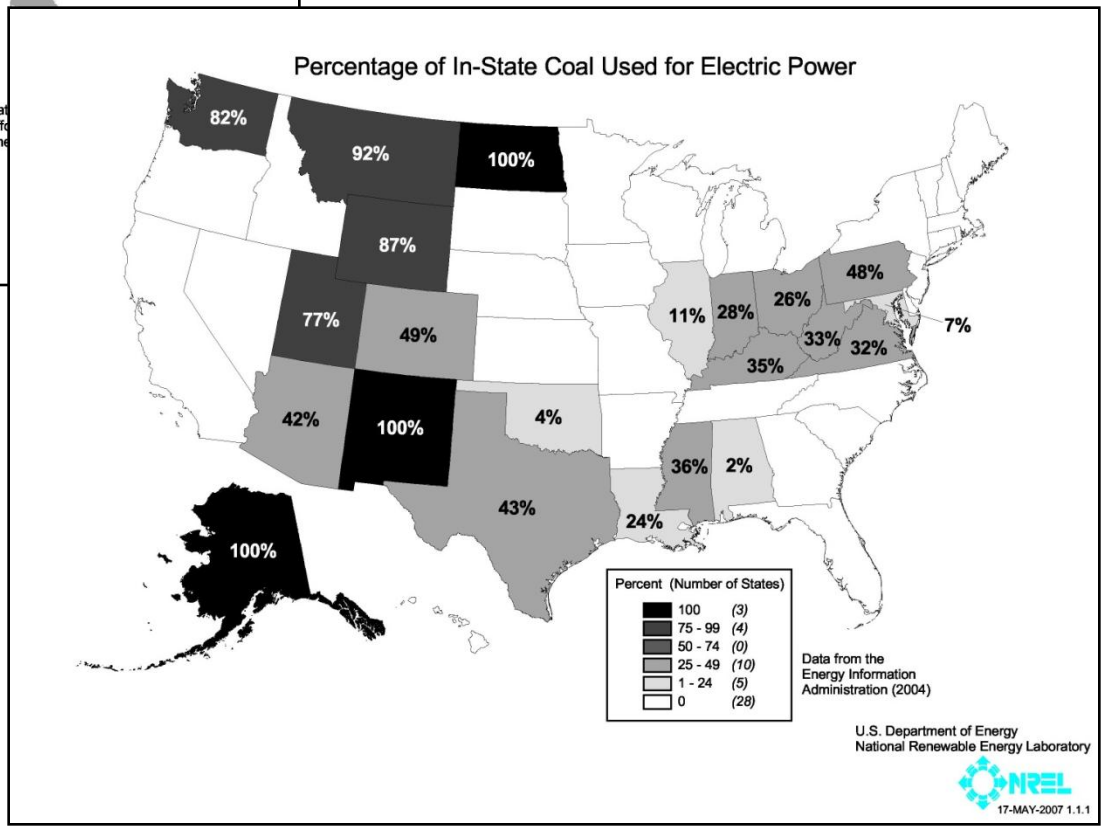


Local Ownership Models

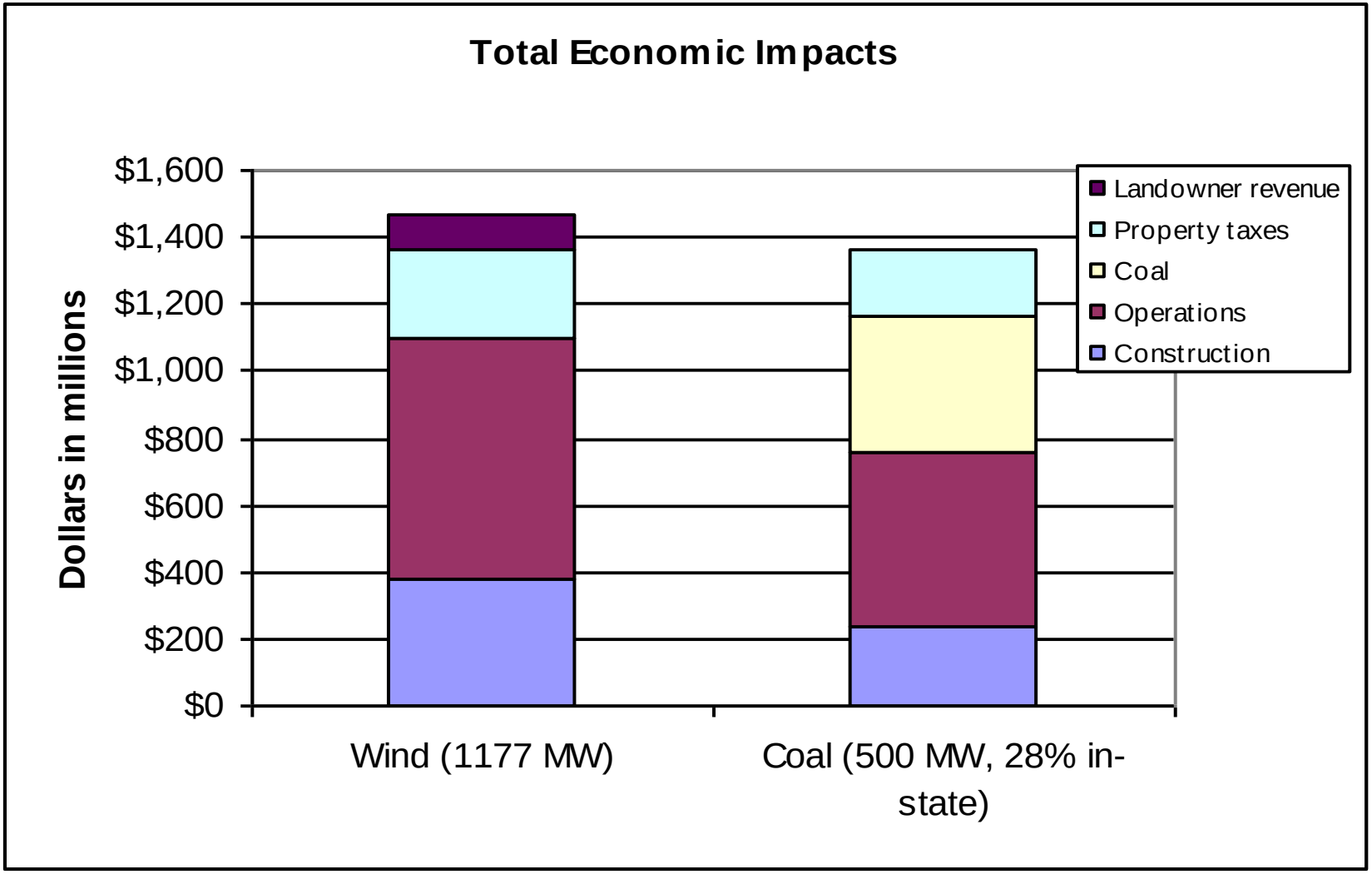
- Minnesota farmer cooperative (Minwind)
- FLIP structure
- Farmer-owned small wind
- Farmer-owned commercial-scale

© L. Kennedy


Percentage of State Electricity from Coal
9%
56%
93%
66%
71%
66%
8%
0%
27%
30%
0%
12%
7%
1%
38%
18%
96%
84%
59%
17%
53%
95%
81%
63%
46%
95%
87%
69%
57%
1%
73%
82%
98%
51%
97%
63%
46%
86%
64%
55%
65%
42%
37%
62%
65%
26%
37%
38%
9%
15%
Percent (Number of States)
75 - 99 (11)
50 - 74 (17)
25 - 49 (10)
1 - 24 (10)
0 (2)

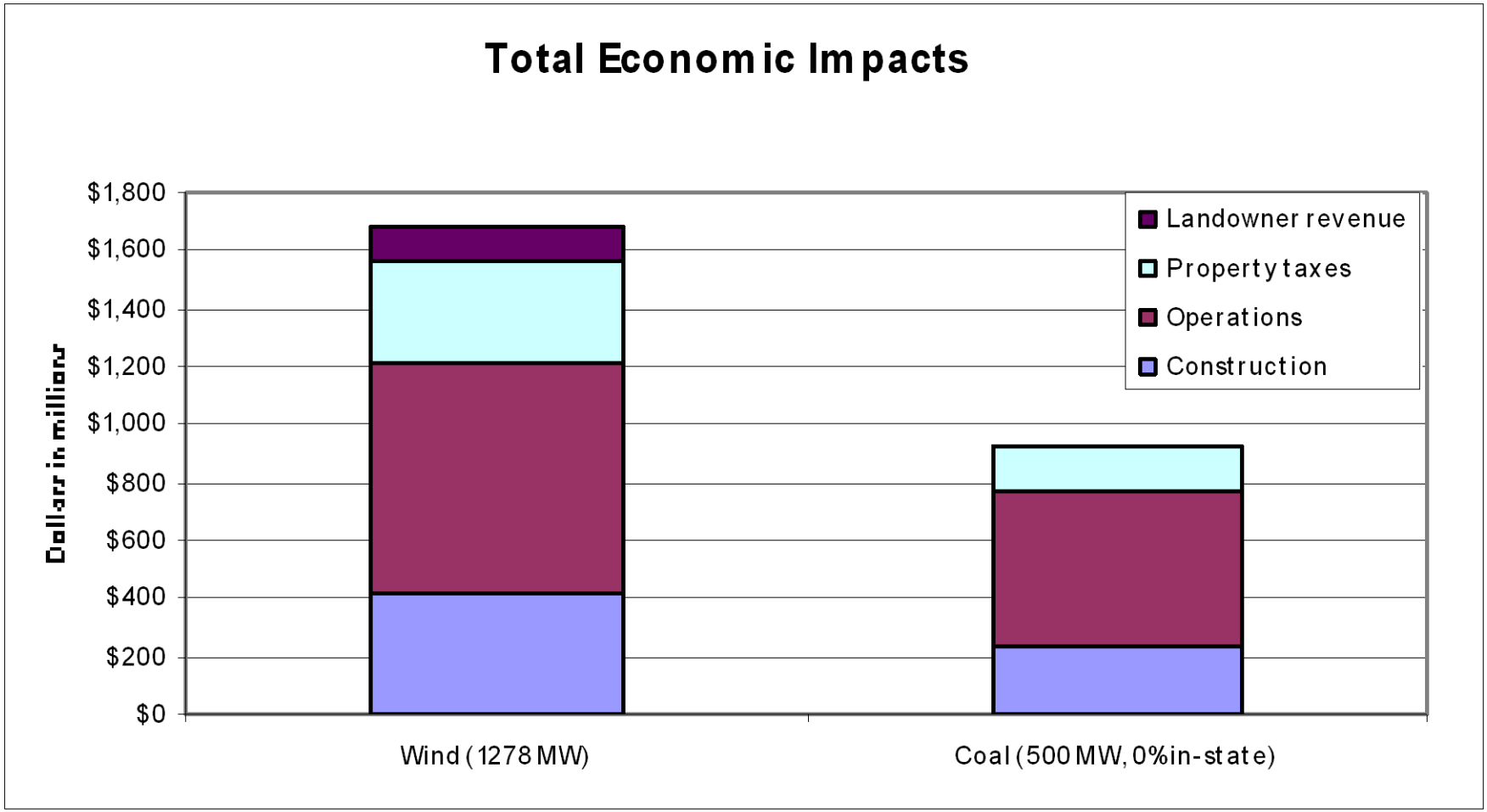

Percentage of In-State Coal Used for Electric Power
82%
92%
100%
87%
48%
11%
28%
26%
7%
77%
49%
33%
32%
35%
42%
100%
4%
36%
2%
43%
24%
100%
Percent (Number of States)
100 (3)
75 - 99 (4)
50 - 74 (0)
25 - 49 (10)
1 - 24 (5)
0 (28)
Data from the Energy Information Administration (2004)
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
17-MAY-2007 1.1.1

Comparing wind and coal in Indiana



Constant 2007 dollars

Comparing wind and coal in Michigan



Constant 2007 dollars

Colorado – Economic Impacts

from 1000 MW of new wind development

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:
- $2.5 Million/yr

Local Property Tax Revenue:
- $4.6 Million/yr

Construction Phase:
- 912 new jobs
- $133.6 M to local economies

Operational Phase:
- 181 new long-term jobs
- $19.3 M/yr to local economies

Indirect & Induced Impacts

Construction Phase:
- 807 new jobs
- $92.7 M to local economies

Operational Phase:
- 129 local jobs
- $15.6 M/yr to local economies

Totals (construction + 20yrs)

Total economic benefit = $924.3 million

New local jobs during construction = 1,719

New local long-term jobs = 310

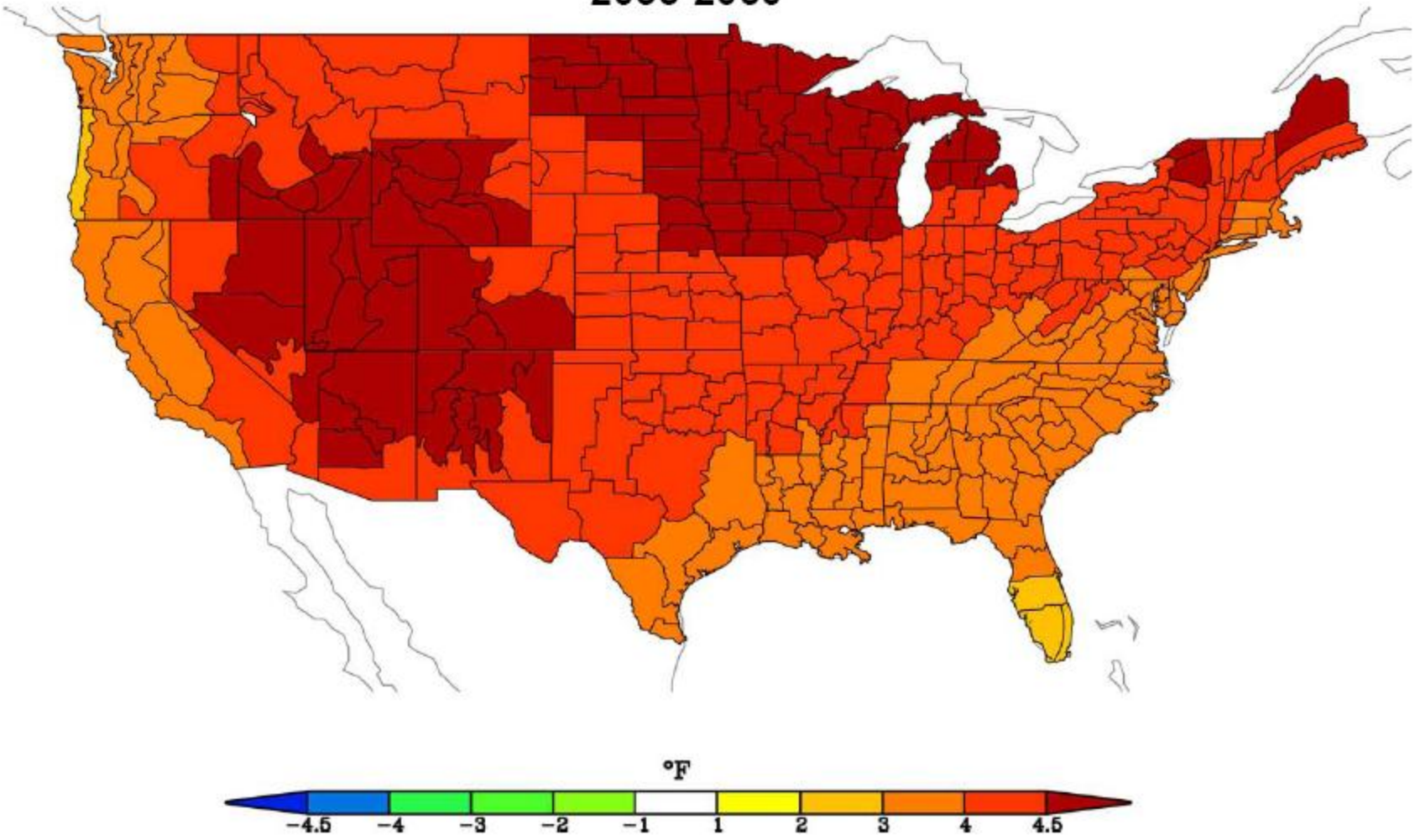
All jobs rounded to the nearest 50 jobs; All values greater than $10 million are rounded to the nearest million

Construction Phase = 1-2 years
Operational Phase = 20+ years

Environmental Benefits

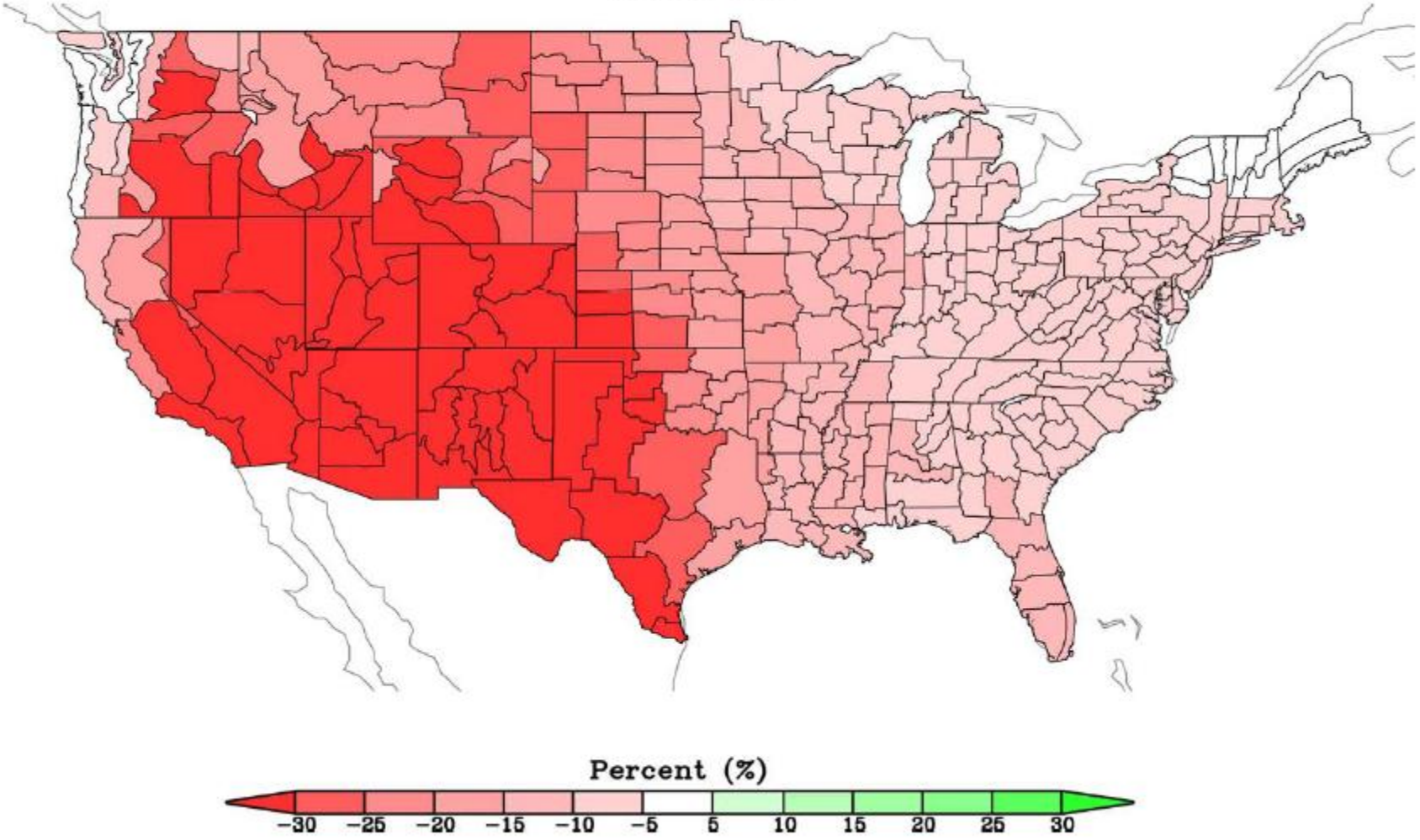
- No SOx or NOx
- No particulates
- No mercury
- No CO2
- No water

Change in Annual Temperature
2035-2060



Source: NOAA

Change in Annual (PCPN-Potential Evapotranspiration) 2035-2060



Source: NOAA

Energy-Water Nexus

Key Issues for Wind Power

- Policy Uncertainty
- Siting and Permitting: avian, noise, visual, federal land
- Transmission: FERC rules, access, new lines
- Operational impacts: intermittency, ancillary services, allocation of costs
- Accounting for non-monetary value: green power, no fuel price risk, reduced emissions

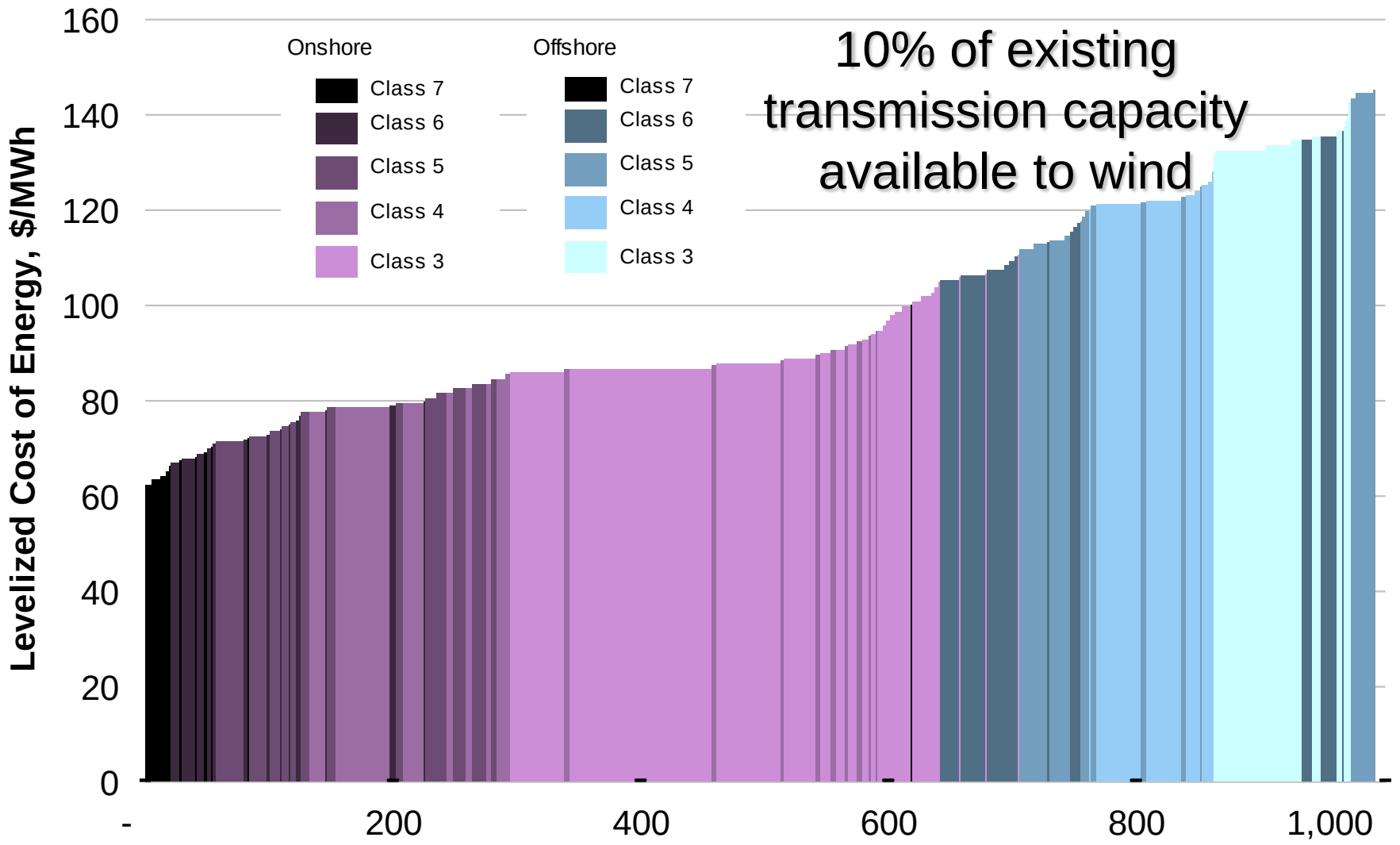
“The future ain’t what it used to be.”

- Yogi Berra

The 20% Technical Report

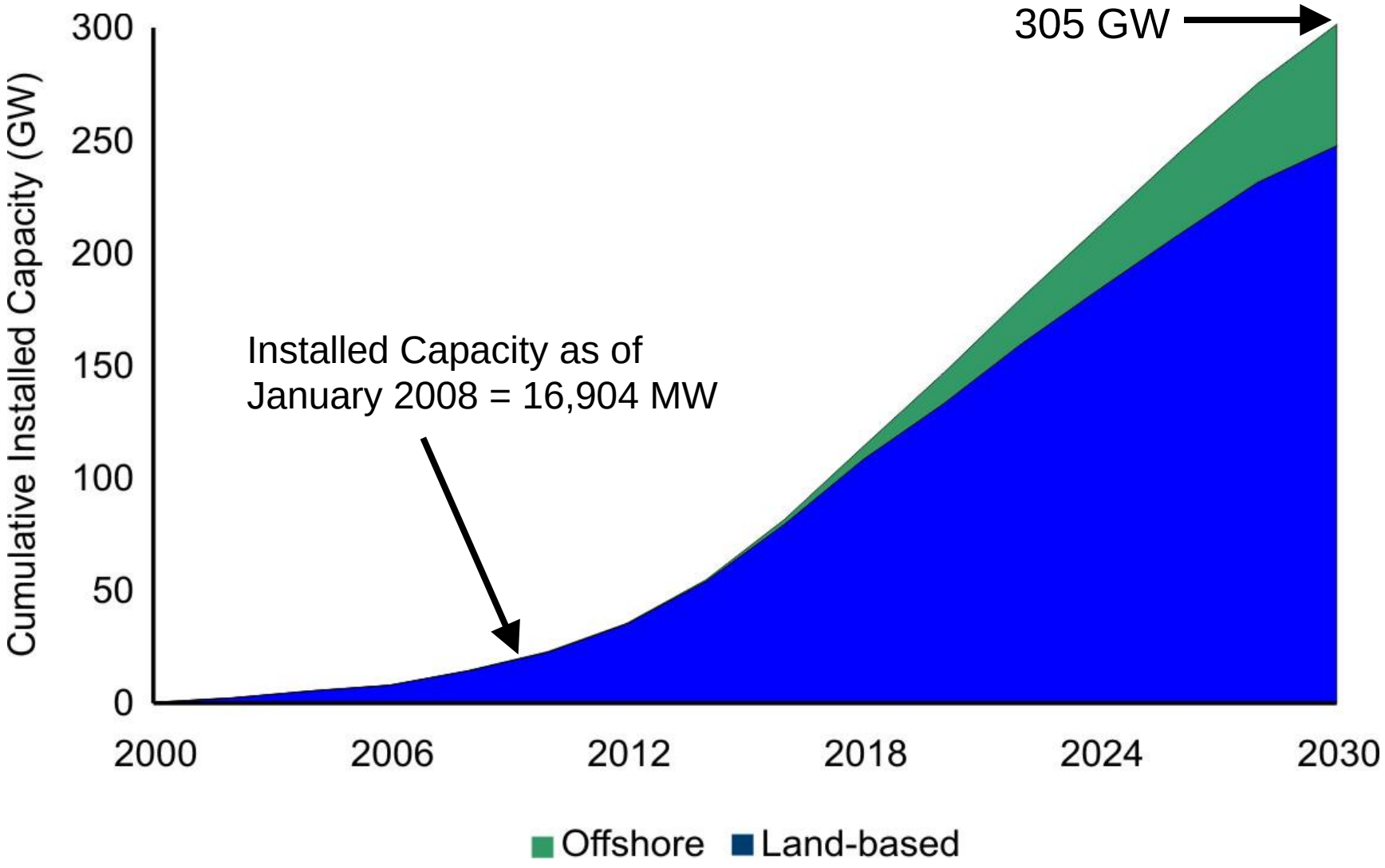
- Explores one scenario for reaching 20% wind electricity by 2030 and contrasts it to a scenario in which no new U.S. wind power capacity is installed
- Is not a prediction, but an analysis based on one scenario
- Does not assume specific policy support for wind
- Is the work of more than 100 individuals involved from 2006 - 2008 (government, industry, utilities, NGOs)
- Critically examines wind's roles in energy security, economic prosperity and environmental sustainability

Supply Curve for Wind Energy: Energy and Transmission Costs

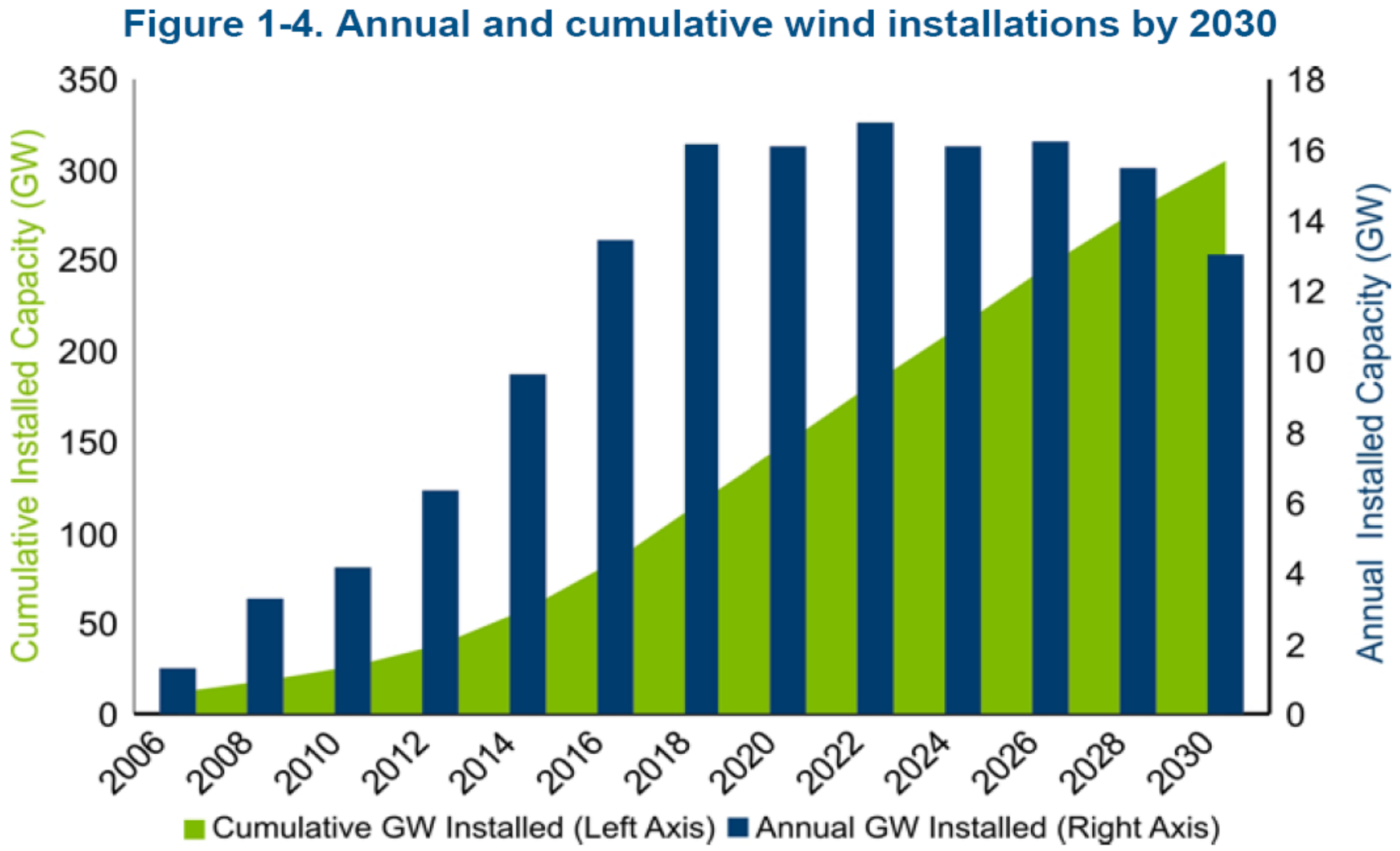


2010 Costs w/o PTC, $1,600/MW-mile, w/o Integration costs

20% Wind Scenario

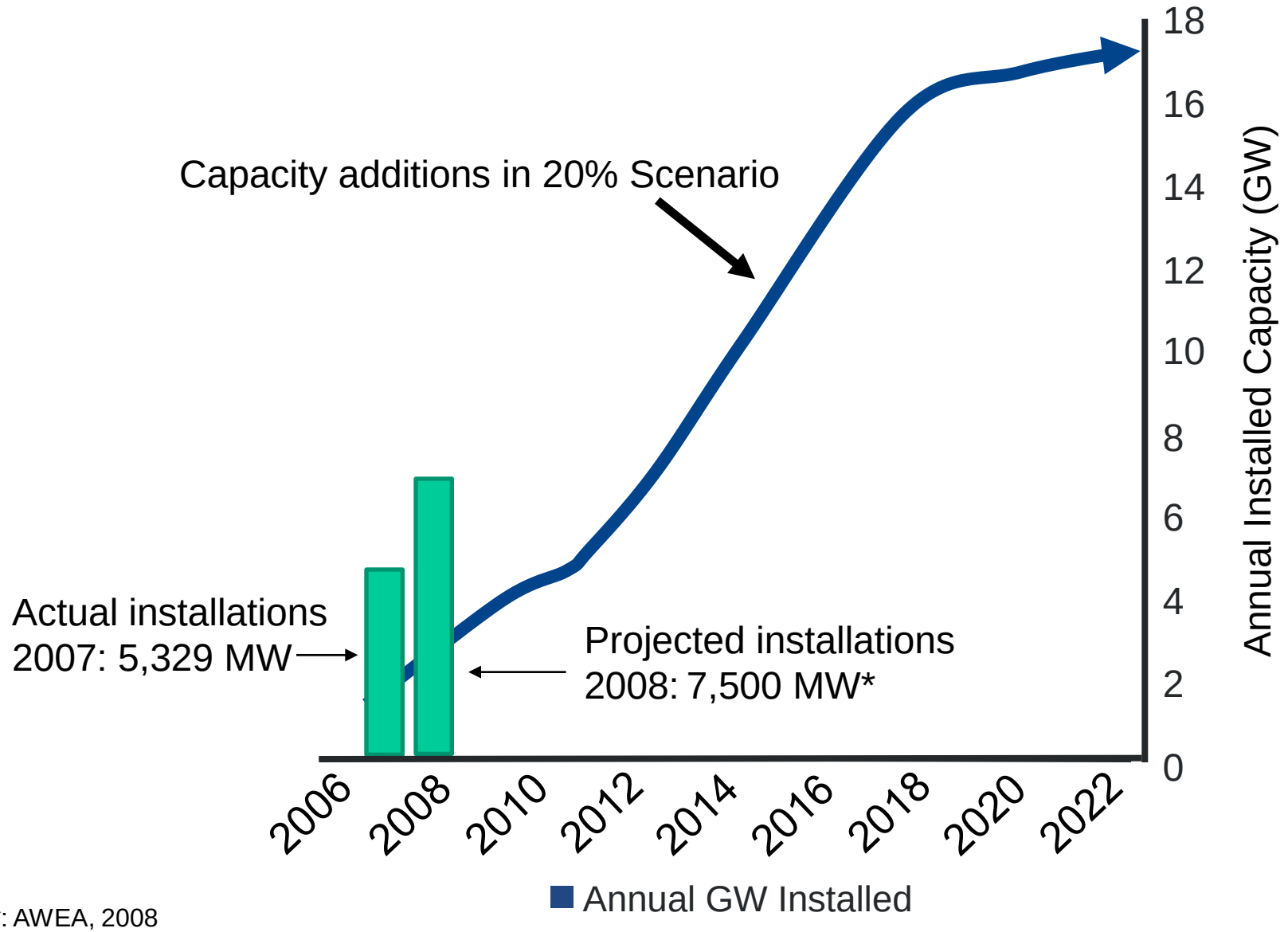


What does 20% Wind look like?



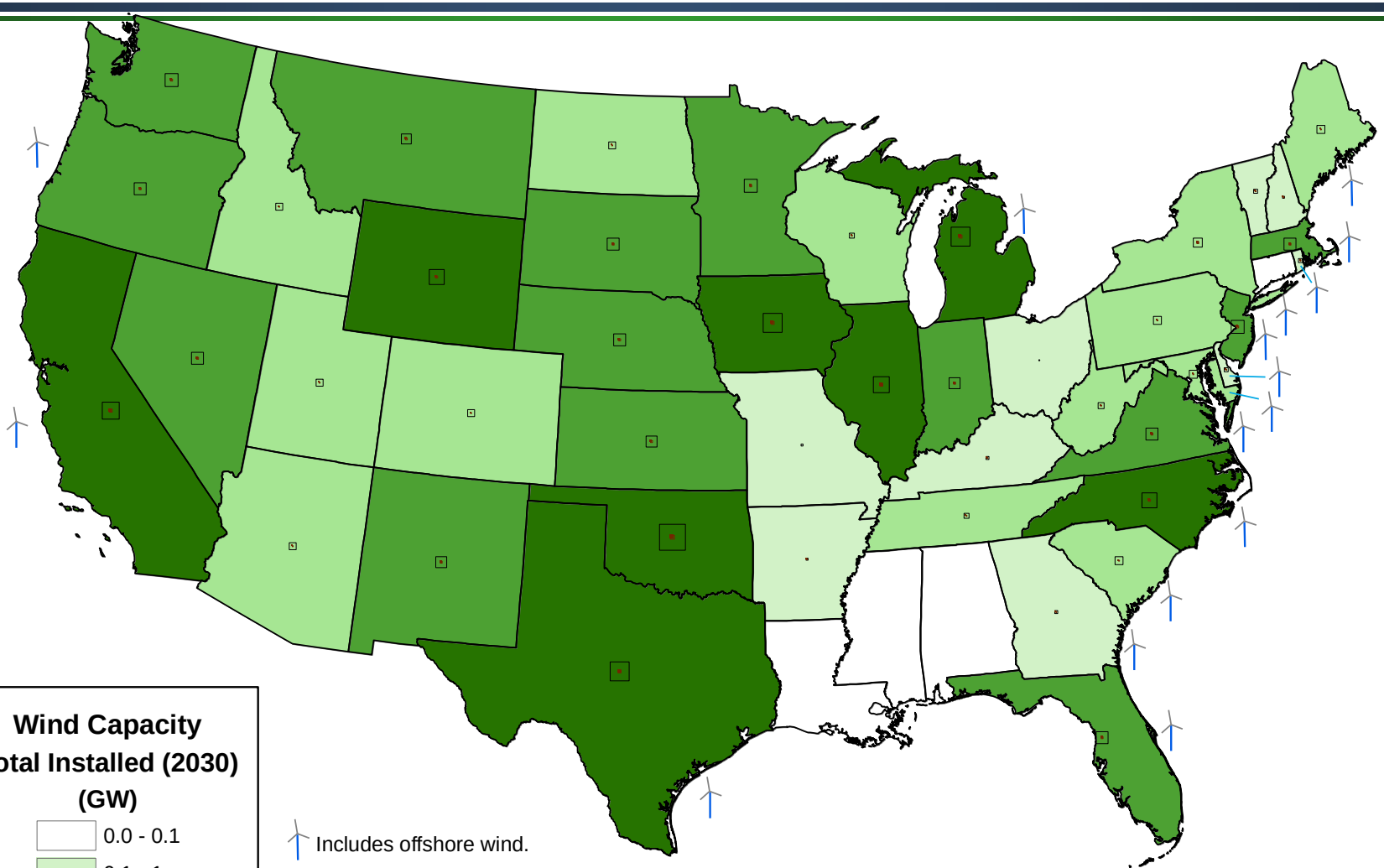
Source: DOE 20% Report

Annual Installed Capacity vs. Current Installed Capacity



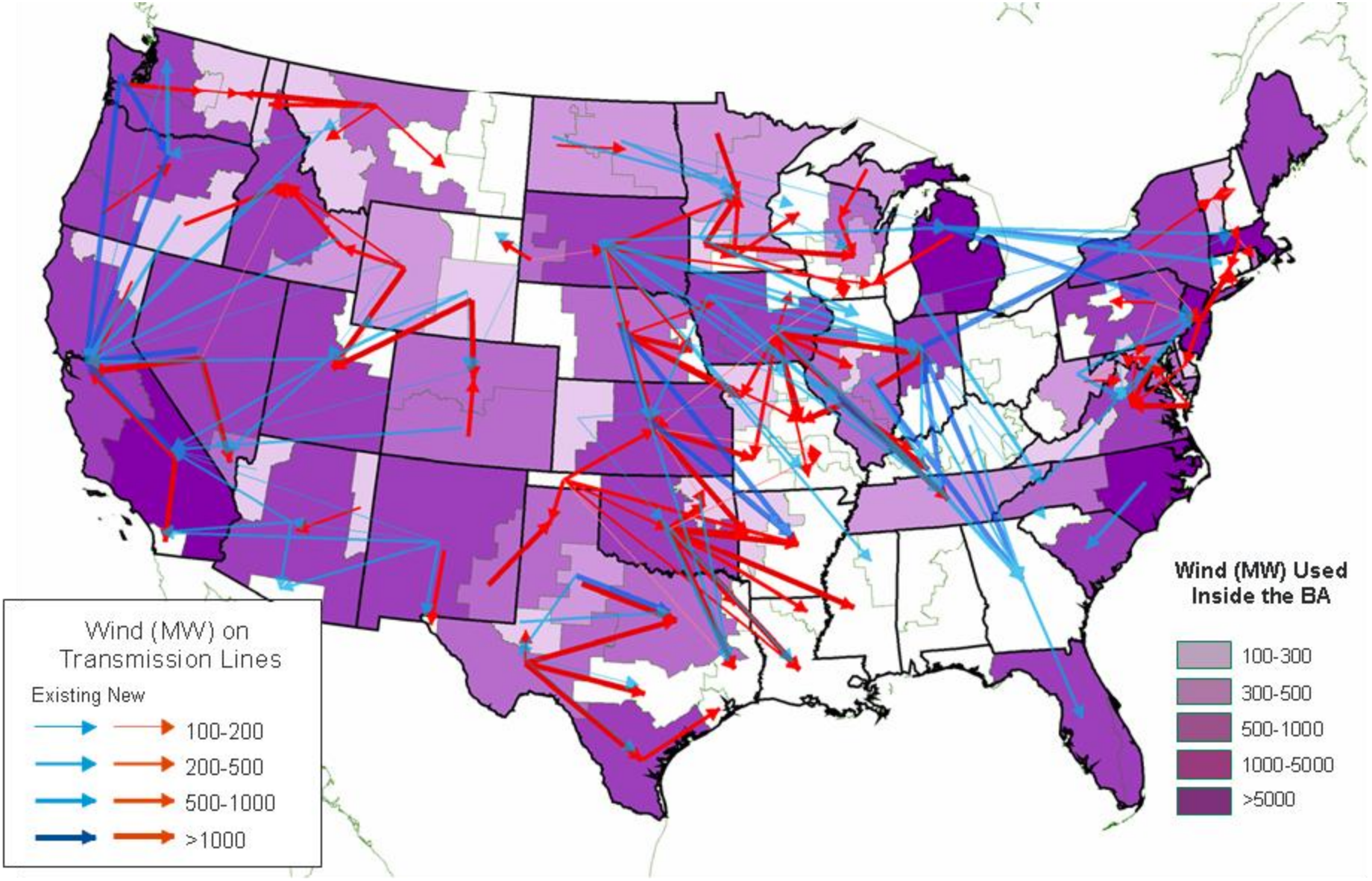
Source*: AWEA, 2008

46 States Would Have Substantial Wind Development by 2030

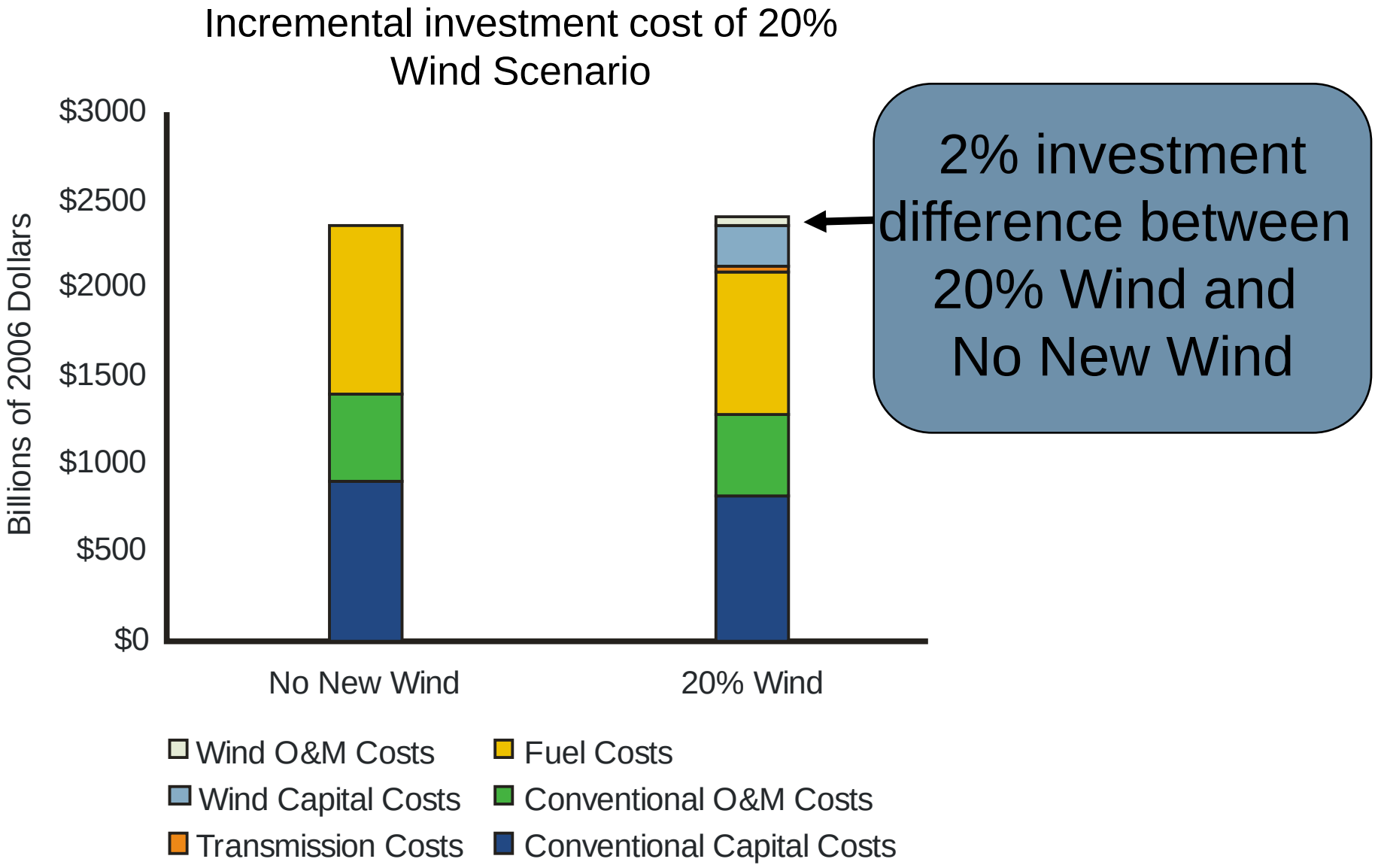


The black open square in the center of a state represents the land area needed for a single wind farm to produce the projected installed capacity in that state. The brown square represents the actual land area that would be dedicated to the wind turbines (2% of the black open square).

Need for New Transmission: Existing and New in 2030

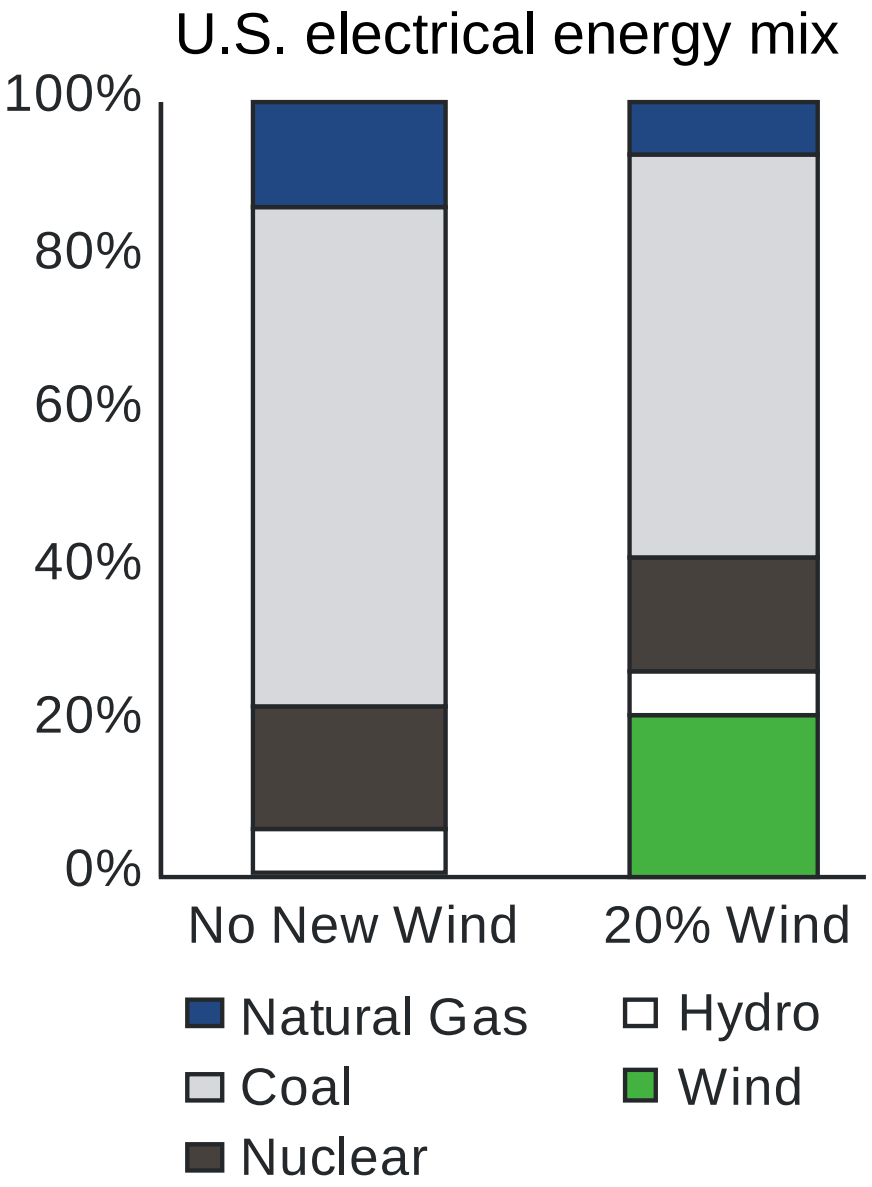


Economic Costs of 20% Wind Scenario



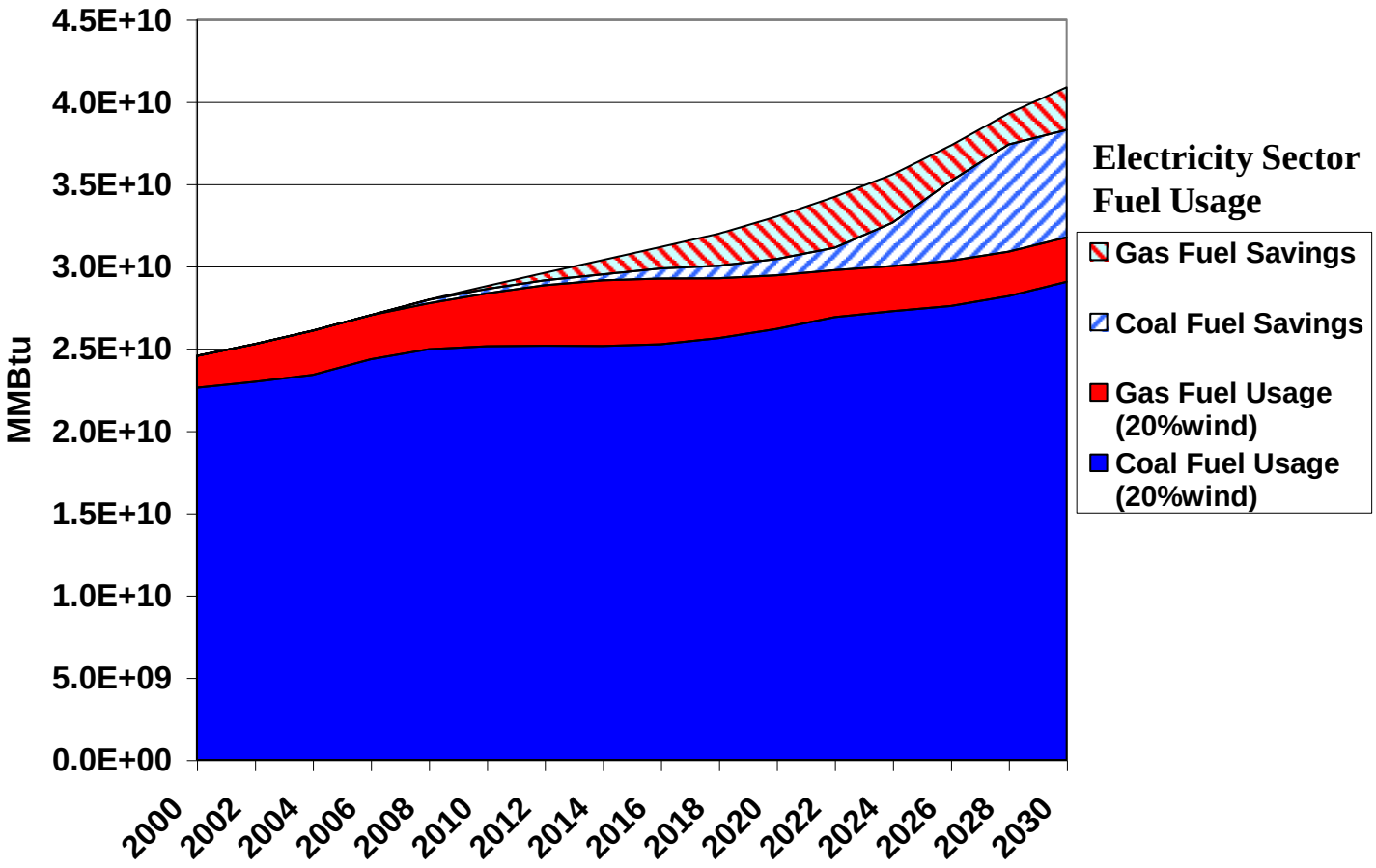
20% Wind Scenario Impact on Generation Mix in 2030

- Reduces electric utility natural gas consumption by 50%
- Reduces total natural gas consumption by 11%
- Natural gas consumer benefits: $86-214 billion*
- Reduces electric utility coal consumption by 18%
- Avoids construction of 80 GW of new coal power plants



Source *: Hand et al., 2008

Fuel Savings from Wind

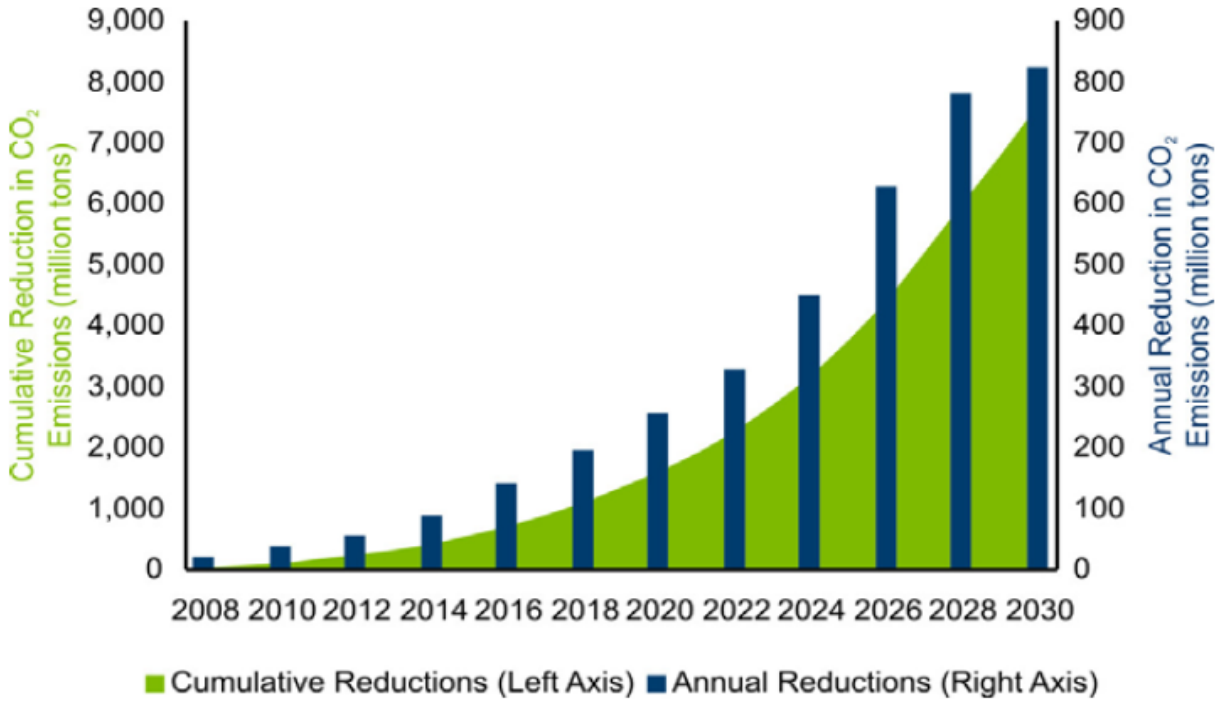


Reduction in National Gas Consumption in 2030 (%)	Natural Gas Price Reduction in 2030 (2006$/MMBtu)	Present Value Benefits (billion 2006$)	Levelized Benefit of Wind ($/MWh)
11%	0.6 -**1.1**- 1.5	86 - **150** - 214	16.6 - **29** - 41.6

Cumulative Carbon Savings

Figure 1-12. Annual CO_2 emissions avoided (vertical bars) would reach 825 million tons by 2030.

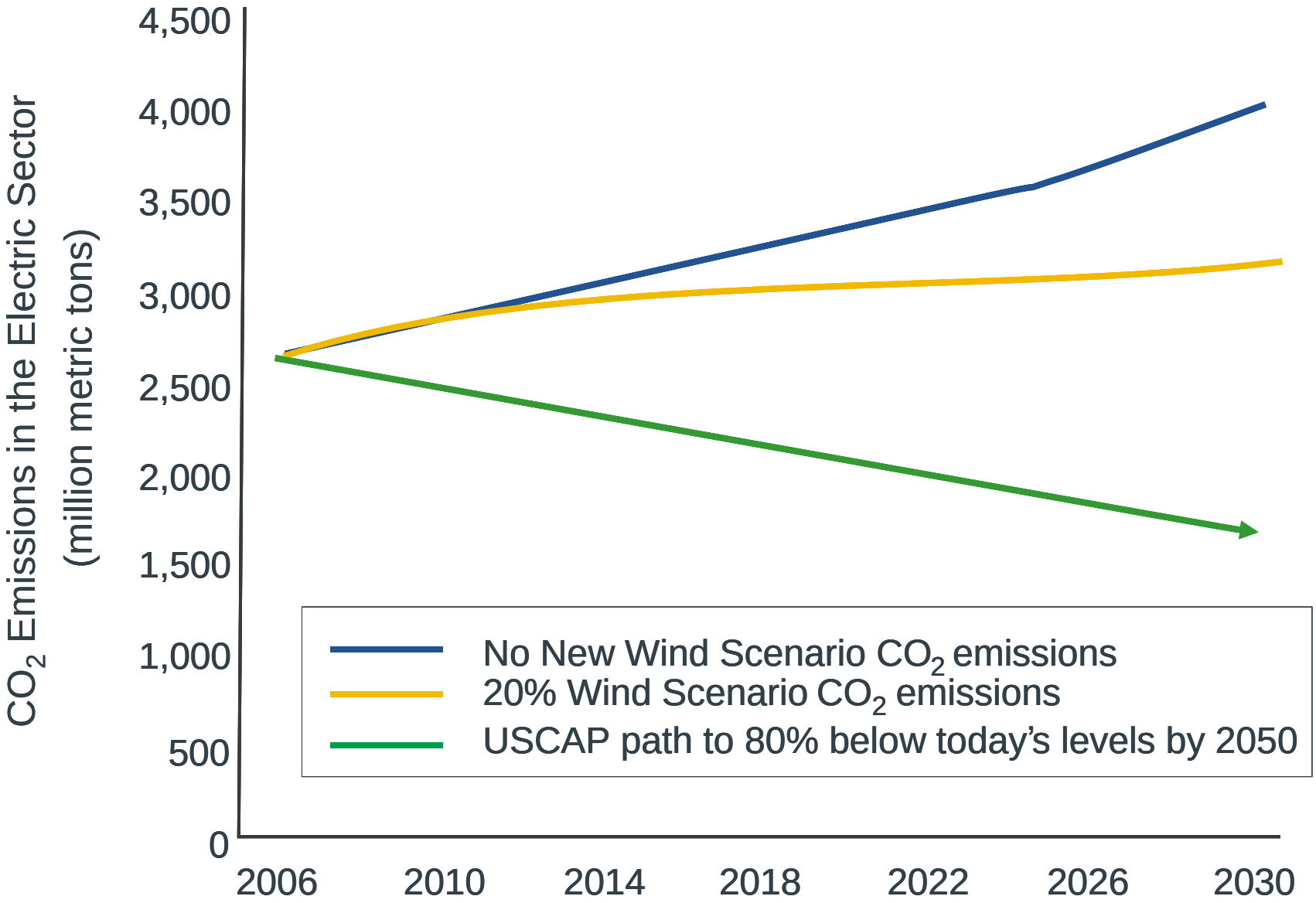
The cumulative avoided emissions by 2030 would total 7,600 million tons.



Cumulative Carbon Savings (2007-2050, MMTCE)	Present Value Benefits (billion 2006$)	Levelized Benefit of Wind ($/MWh-wind)
4,182 MMTCE	$ 50 - $145	$ 9.7/MWh - $ 28.2/MWh

Source: DOE 20% Vision Report

CO2 Emissions from the Electricity Sector



National (U.S.) – Economic Impacts

Cumulative impacts from 2007-2030

From the 20% Scenario- 300 GW new Onshore and Offshore development

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:
- $782 M

Local Property Tax Revenue:
- $1,877 M

Construction Phase:
- 1.75 M FTE jobs
- $ 293 B to the US economy

Operations:
- 1.16 M FTE jobs
- $122 B to the US economy

Indirect & Induced Impacts

Construction Phase:
- 4.46 M FTE jobs
- $651 B to the US economy

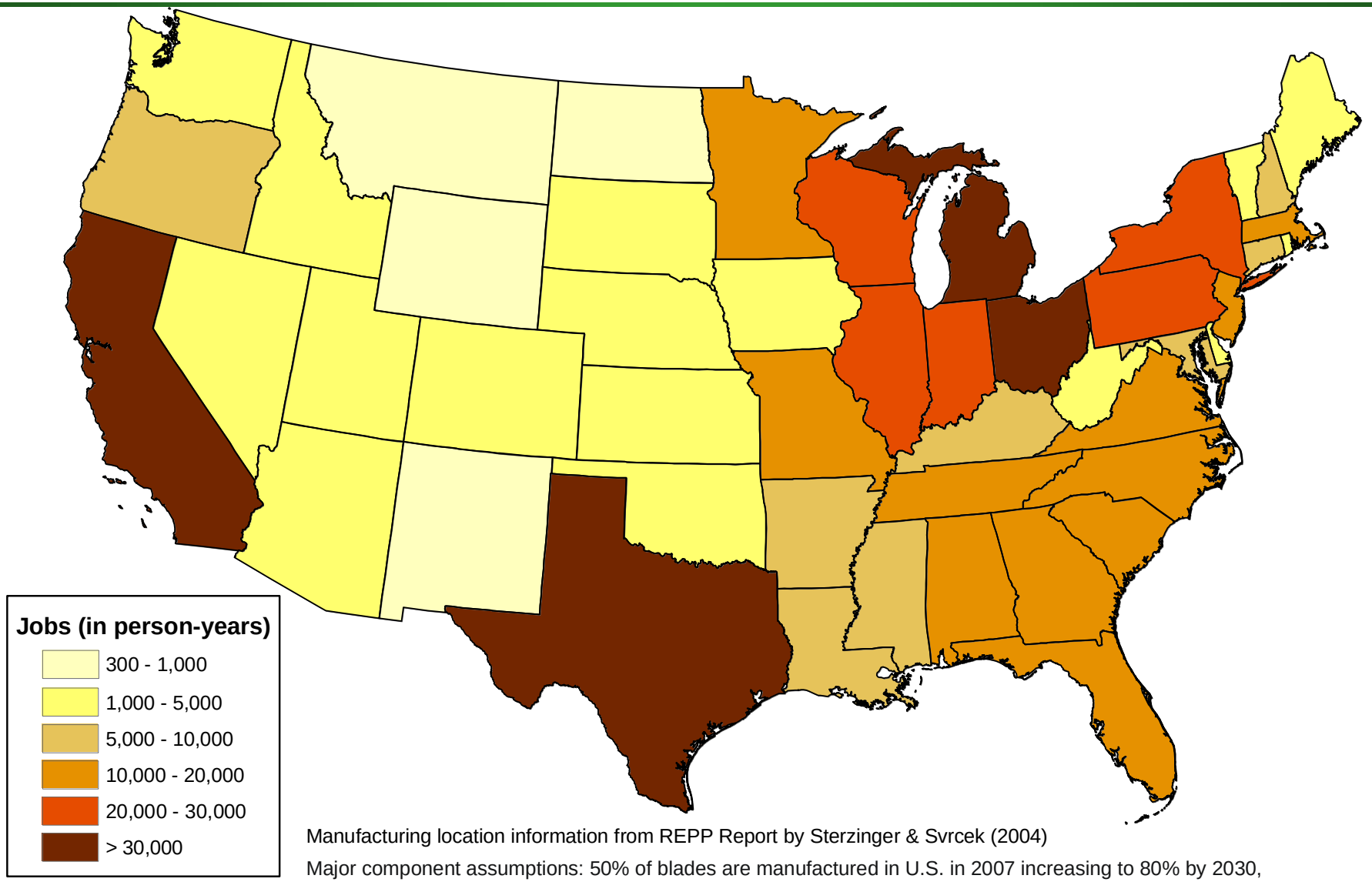
Operations:
- 2.15 M FTE jobs
- $293 B to the US economy

Totals (construction + 20yrs)

- **Total economic benefit** = $1,359 B
- **New jobs during construction** = 6.2 M FTE jobs
- **New operations jobs** = 3.3 M FTE jobs

All monetary values are in 2006 dollars.
Construction Phase = 1-2 years

Manufacturing Jobs Supported by State

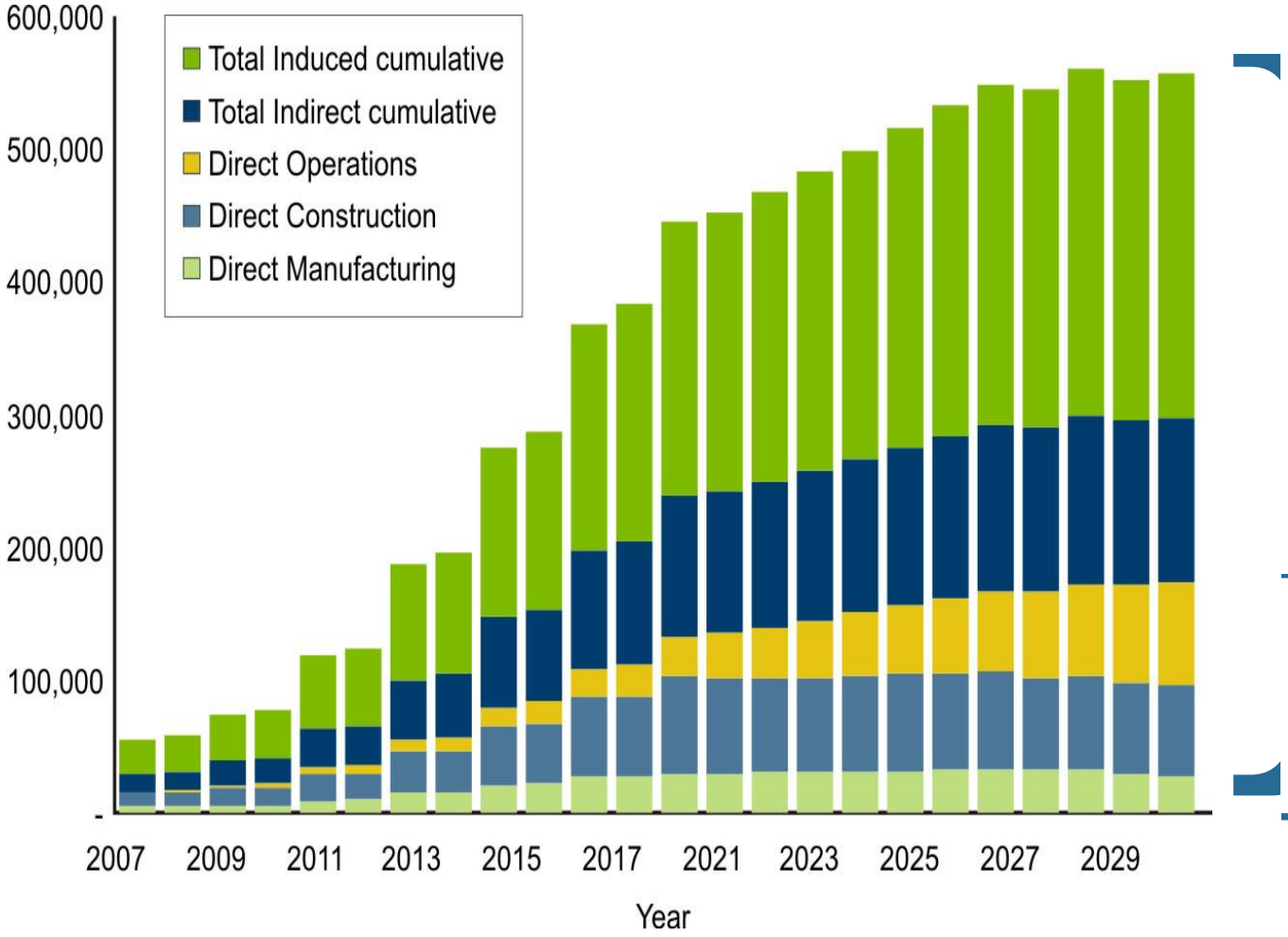


Manufacturing location information from REPP Report by Sterzinger & Svrcek (2004)

Major component assumptions: 50% of blades are manufactured in U.S. in 2007 increasing to 80% by 2030, 26% of towers are from the U.S. in 2007 increasing to 50% by 2030 and 20% of turbines are made in the U.S. increasing to 42% by 2030.

Jobs Supported by the 20% Scenario

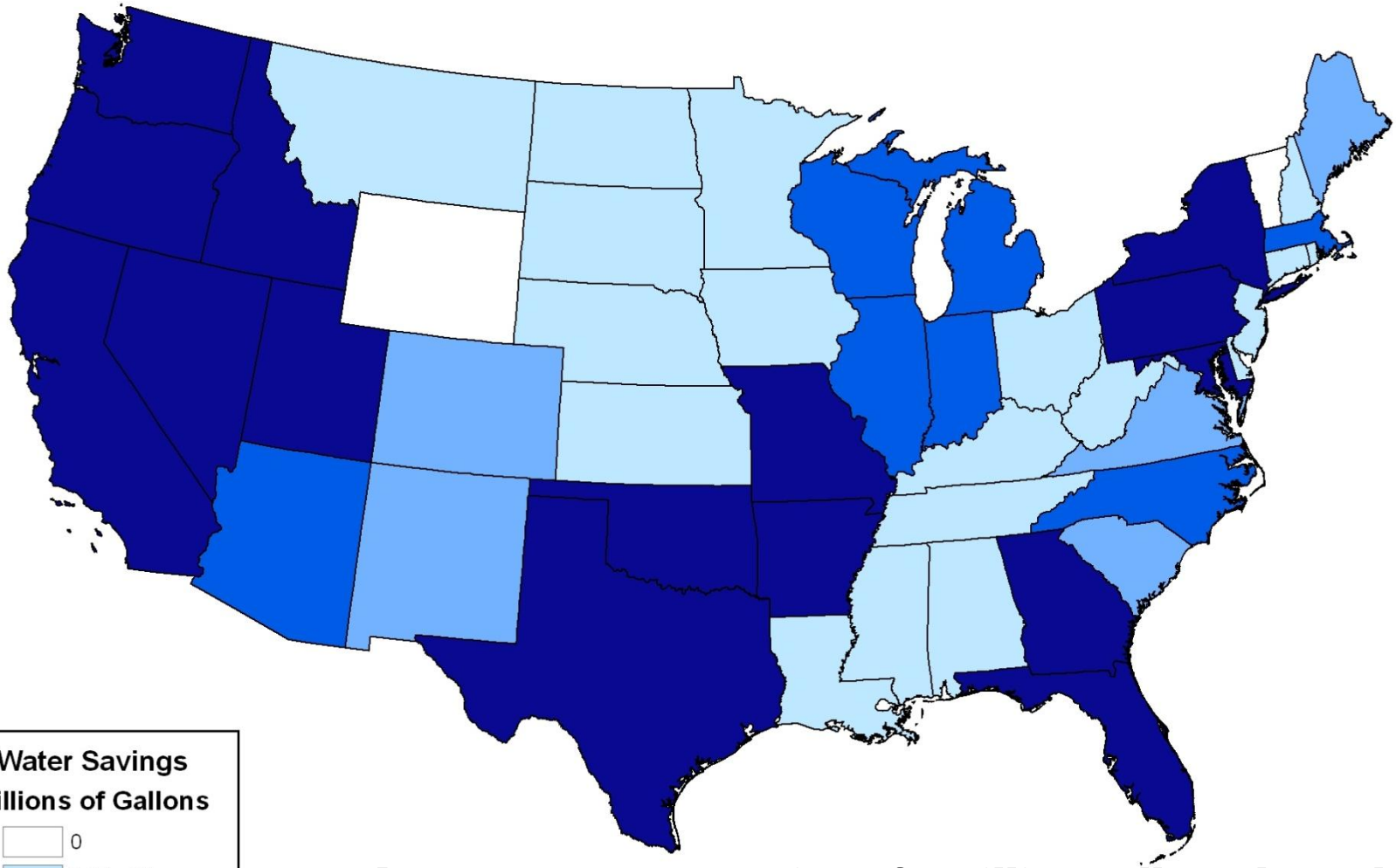
Over 500,000 jobs would be supported between 2007 and 2030



Over 500,000 jobs supported by the industry in 2030

Approx. 180,000 directly employed by wind

Cumulative Water Savings from 20% Scenario



Reduces water consumption of 4 trillion gallons through 2030 (represents a reduction in electric sector water consumption by 17% in 2030)

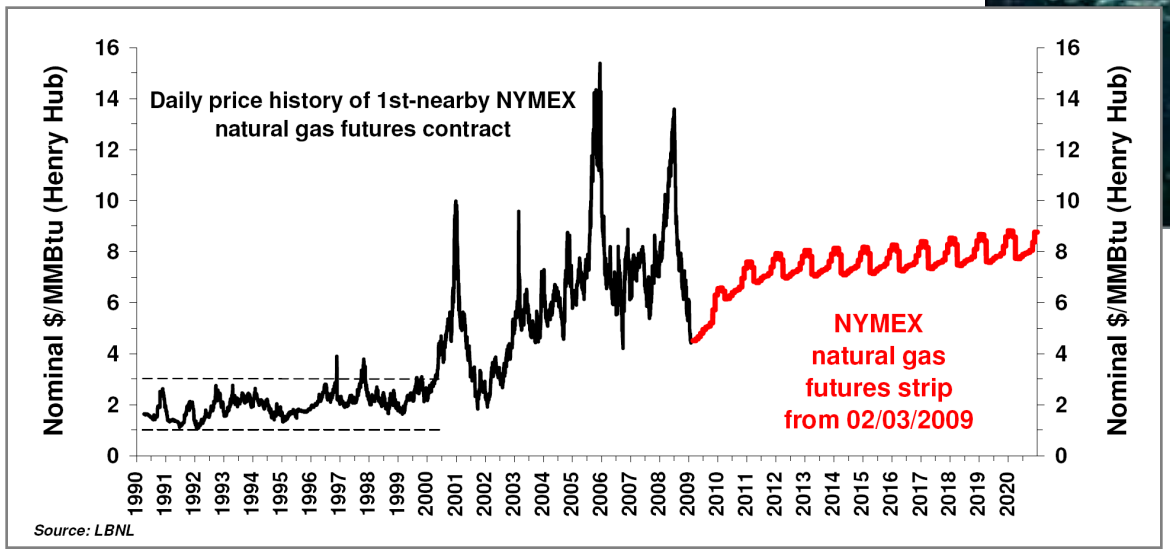
Wind Power Avoids Other Negative Impacts

- Wind power avoids the negative impacts of fossil fuel-based electricity generation:
  - Air emissions of mercury or other heavy metals
  - Emissions from extracting and transporting fuels
  - Lake and streambed acidification
  - Production of toxic solid wastes, ash, or slurry

Photo courtesy: NREL

Other Benefits of 20% Wind Energy

- Improves energy security by diversifying electricity portfolio with an indigenous energy source
- Reduces fossil fuel demand and fuel prices, helping to stabilize electricity rates



Results: Costs & Benefits

Incremental direct cost to society	**$43 billion**
Reductions in emissions of greenhouse gasses and other atmospheric pollutants	825 M tons (2030) **$98 billion**
Reductions in water consumption	8% total electric 17% in 2030
Jobs created and other economic benefits	150,000 direct $450 billion total
Reductions in natural gas use and price pressure	11% **$150 billion**
Net Benefits: $205B + Water savings	

Conclusions

- 20% wind energy penetration is possible
- 20% penetration is not going to happen under business as usual scenario
- Policy choices will have a large impact on assessing the timing and rate of achieving a 20% goal
- Key Issues: market transformation, transmission, project diversity, technology development, policy, public acceptance
- 20% Vision report: May 2008 (www.20percentwind.org)

Carpe Ventem

www.windpoweringamerica.gov